

The Farm Level Economic Impacts for Western Canadian Cow-Calf Producers Accessing the EU Market

A Thesis

Submitted to the College of Graduate and Postdoctoral Studies
in Partial Fulfillment of the Requirements
for the Degree of
Master of Science

In the Department of
Agricultural and Resource Economics
University of Saskatchewan
by
Amanda Gabruch

PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a postgraduate degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professors who supervised my thesis work, or in their absence, the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition will be given to me and the University of Saskatchewan in any scholarly use that may be made of any material in this thesis. Requests for permission to copy or to make other use of the material in this thesis in whole or part should be addressed to:

Head of the Department of Agricultural and Resource Economics

University of Saskatchewan

51 Campus Drive

Saskatoon, Saskatchewan S7N 5A8

ABSTRACT

Gabruch, Amanda L. M.Sc. University of Saskatchewan, Saskatoon, September 2017. *The Farm Level Economic Impacts for Western Canadian Cow-Calf Producers Accessing the EU Market*

Supervisor: Dr. Eric Micheels

The Canadian beef industry applauded the recent signing of the Comprehensive Economic and Trade Agreement, which will enable greater to access the valuable EU beef market. Despite the enthusiasm surrounding this trade opportunity, the commercial viability of producing for the EU market is still unknown for the cow-calf sector. Thus, the objective of this research is to estimate the premium required by cow-calf producers so that the benefit of enrolling in the EU program for certifying growth enhancing product free beef would outweigh the additional production costs.

To address this objective, a break-even (BE) price is simulated under various production scenarios before and after the necessary adjustments are made to become EU compliant. The difference between these simulated break even prices represents an estimate of the required premium. Producers must be offered at least this premium to overcome the additional production costs imposed for compliance. The resulting estimates suggest that the BE difference ranges from \$2.13 to \$34.78 per calf, depending on the practices already in place prior to enrolling. Given the market conditions over the past decade, premiums as high as \$60.12 per head would be required for some producers to maintain their profitability.

Besides quantifying costs for EU certification, this research speaks to a greater narrative on the economic considerations of accessing new markets that require certain production attributes. Although these markets may offer higher values, it is important to balance potentially

larger revenues with additional costs. Thus, this research offers a framework by which the impact of changing production regimes on profit may be simulated.

ACKNOWLEDGEMENTS

The first person to acknowledge for completion of this thesis is my supervisor, Dr. Eric Micheels. Not only did he support this process, but also encouraged me to pursue many other opportunities which resulted in great accomplishments and experiences as well. Immediately following Dr. Micheels, gratitude is owed to my committee members, Dr. Jill Hobbs and Dr. William Kerr, who put much of their valuable time into offering helpful advice and thoughtful suggestions for improving this thesis. Finally, I must also thank Kathy Larson at the WBDC for taking time to offer me a wealth of information in regards to the cost of production data that is relied upon heavily for this research.

My parents certainly deserve credit for all of their support throughout the pursuit of my Master's degree, as well as during the years that preceded it, which certainly made my successes possible. Oddly, I also feel the need to thank them for a childhood spent, although sometimes begrudgingly, doing chores, working cows, and fixing fence. Words cannot express how valuable the dirt under my fingernails was to the process of writing this thesis, as it allowed me to easily understand the farm-level impacts and skip some learning curves.

Last, but not least, I owe much gratitude to the other students in my program. They definitely had a major hand in the maintenance of my sanity throughout grad school, which was trying at times to say the least. It is my hope that I adequately returned the favor and they look back on this time with fond memories, as I one day will.

TABLE OF CONTENTS

Permission to Use.....	i
Abstract.....	ii
Acknowledgements.....	iv
Table of Contents.....	v
List of Tables.....	vii
List of Figures.....	viii
Chapter 1: Introduction and Background.....	1
1.1 Introduction.....	1
1.2 Background.....	2
1.2.1 Beef Trade with the EU.....	2
1.2.2 EU Ban on Growth Enhancing Technology.....	4
1.2.3 Growth Enhancing Technology Use in Canadian Beef Production...7	
1.3 Exporting Canadian Beef to the EU.....	10
1.4 Motivation and Objectives.....	12
Chapter 2: Literature Review.....	14
2.1 Introduction.....	14
2.2 Cow-Calf Production.....	14
2.2.1 Feed.....	15
2.2.2 Economies of Size.....	16
2.2.3 Biological Performance.....	19
2.3 Economics of Alternative Beef Production Systems.....	20
2.4 Systems Modelling and Beef Production Economics.....	24
2.5 Summary.....	32
Chapter 3: Conceptual Framework.....	34
3.1 Introduction.....	34
3.2 Procuring EU Compliant Calves.....	34
3.2.1 Profit Incentive.....	35
3.2.2 Accessing the EU Supply Chain.....	36
3.3 Measuring Profit Incentive.....	39
3.3.1 Drivers of Break Even Price.....	41
3.4 Model Development.....	43
3.5 Elements of Compliance.....	46
3.5.1 Production without GEPs.....	46
3.5.2 Record Keeping, Identification and Administrative Tasks.....	47
3.6 Compliance Scenarios.....	51
3.6.1 Scenario A.....	53
3.6.2 Scenario B.....	54
3.6.3 Scenario C.....	54
3.6.4 Scenario D.....	55
3.7 Conceptual Systems Model.....	56

Chapter 4: Empirical Framework.....	57
4.1 Introduction.....	57
4.2 Exogenous Variables.....	62
4.2.1 Herd Size.....	62
4.2.2 Weaning Percentage.....	63
4.2.3 Calving Percentage.....	63
4.2.4 GEP Response.....	63
4.2.5 Base Weight.....	64
4.2.6 Binary Decision Variables.....	65
4.3 Endogenous Variables.....	69
4.3.1 Weaning Weight.....	69
4.3.2 Calves Weaned.....	70
4.3.3 Total Production.....	70
4.3.4 Labour Costs.....	70
4.3.5 Direct Costs.....	73
4.3.6 Yardage Costs.....	74
4.3.7 Other Costs.....	75
4.3.8 Total Production Costs.....	75
4.3.9 Break Even.....	76
4.4 Chapter Summary.....	76
Chapter 5: Results.....	80
5.1 Introduction.....	80
5.2 Simulation Results.....	81
5.2.1 BE For Compliant Production.....	81
5.2.2 Scenario A.....	82
5.2.3 Scenario B.....	83
5.2.4 Scenario C.....	84
5.2.5 Scenario D.....	85
5.2.6 Weighted Average Sensitivity Analysis.....	85
5.2.7 Supply of EU Certified Cattle.....	86
5.3 Production Sensitivity Analysis.....	88
5.3.1 Weaning Weight.....	89
5.3.2 Weaning Percentage.....	90
5.3.3 Implant Response.....	91
5.4 Price Sensitivity Analysis.....	92
5.5 Chapter Summary.....	94
Chapter 6: Summary and Conclusions.....	96
6.1 Summary.....	96
6.2 Limitations.....	98
6.3 Conclusions.....	100
6.4 Areas for Further Research.....	105
References.....	106
Appendix A: Tag Replacement Report.....	117
Appendix B: Register for Birth Farms.....	118
Appendix C: Transfer Certificate.....	119
Appendix D: Weighted Average Sensitivity Analysis.....	121

LIST OF TABLES

Table 3.1: Summary of Compliance Scenarios.....	55
Table 4.1: Provincial COP Survey Results.....	61
Table 4.2: Approved Products for Suckling Calves in Canada.....	67
Table 4.3: Exogenous Variable Summary.....	78
Table 4.4: Endogenous Variable Summary.....	79
Table 5.1: Summary of Results.....	82
Table 5.2: Supply of Calves.....	87
Table 5.3: Base Weaning Weight Sensitivity.....	90
Table 5.4: Weaning Percentage Sensitivity.....	91
Table 5.5: Implant Response Sensitivity.....	92
Table 5.6: Profit Margin Sensitivity.....	94

LIST OF FIGURES

Figure 3.1: Break-Even Direct Drivers.....	44
Figure 3.2: Break-Even Second Level Drivers.....	44
Figure 3.3: Break Even Third Level Drivers.....	45
Figure 3.4: RFID Tag.....	48
Figure 3.5 RFID and Dangle Tag.....	50
Figure 3.6: Conceptual Model.....	56
Figure 4.1: Beef Cow Inventory Canada and the Prairie Provinces.....	59
Figure 4.2: Structure of Empirical Model.....	77

CHAPTER 1 – INTRODCUTION AND BACKGROUND

1.1 Introduction

Recently the Canadian beef industry secured greater access to the European Union (EU) beef market with the signing of the Comprehensive Economic and Trade Agreement (CETA). Although this breakthrough was met with enthusiasm by the industry, beef trade with the EU is constrained by several technical barriers (Canadian Cattlemen's Association, 2014; Canadian Food Inspection Agency, 2016). Thus, the purpose of this thesis is to examine the cost that compliance with EU beef import regulations presents to western Canada's cow-calf producers, who must alter certain production and record keeping practices to be in compliance. As beef must be produced and processed to EU standards at every step of the supply chain, cow-calf producer participation in the EU program for certifying growth enhancing product (GEP) free beef is necessary to procure a supply of certified cattle and take advantage of increased EU market access.

The contribution of this work is two-fold; it estimates a premium that cow-calf producers would require to cover the additional costs of EU compliance, and it develops a systems model that can simulate production costs under EU certification practices as well as conventional practices. This model adds to a growing literature which employs systems modelling methodology to the research of various aspects of beef production in North America. More specifically, it represents another example for quantifying the economic impacts of alternative beef production practices, like the works of Capper and Hayes (2012), Lawrence and Ibubaru (2007) and Olvera (2016). However, this contribution remains novel in its focus on western Canada, and specific interest in the EU market channel specifications, for which no other literature was found that explicitly values the cost of complying amongst cow-calf producers.

This thesis proceeds with a detailed discussion on beef trade with the EU and the existing technical barriers to trade for Canadian beef. Next, the literature covering production economics, alternative production and systems modelling applications to cow-calf research is surveyed. The findings of these contributions are used to develop a conceptual framework for modelling the impact of following EU certification procedures on farm-level production costs. This framework is then parameterized using data from various sources to develop a working model that can quantify these impacts. Finally, the simulation results are presented and interpreted in the context of production costs alone as well as overall profitability to offer an estimate of the price premium cow-calf producers would require to enter the EU market channel.

1.2 Background

1.2.1 Beef Trade with the EU

International trade is important for the Canadian beef industry, as a large proportion of its production enters the export market. Over the past decade, annual Canadian beef exports have averaged 430,000 tonnes, which amounts to 36 percent of total production (Statistics Canada, 2016). Globally, Canada is the sixth largest exporter of beef, despite the fact that it does not even make the top 10 beef producing nations (US Department of Agriculture, 2016). Due to the significant role trade plays, development of a trade agreement between Canada and the EU was met with much enthusiasm by the Canadian beef industry (Canadian Cattlemen's Association, 2014).

The CETA, which was signed October 30th 2016, will eliminate 98 percent of tariffs for Canadian goods entering the EU, with further reductions over several years. This agreement could open up many new trade opportunities for Canadian businesses, as previously only 25

percent of tariff lines for Canadian goods were duty-free going into the EU (Government of Canada, 2016). For Canadian beef, duty-free market access for a total of 64,950 tonnes (carcass weight equivalent) will come into effect over five years. Immediately following the enforcement of CETA, Canada's existing portion of the high-quality beef quota, which previously allowed 14,950 tonnes to enter the EU at a 20 percent within-quota tariff, would be allowed in duty-free. Over the next five years, quotas for 35,000 tonnes of fresh or chilled and 15,000 tonnes of frozen beef and veal products will gradually be allowed to enter duty-free as well (Government of Canada, 2016). This trade opportunity could represent a \$600 million dollar value to Canadian beef producers (Canadian Cattlemen's Association, 2014).

However, the potential benefits of trade with the EU can only be fully realized if the tariff-free quota is filled. In 2015, 326 tonnes of chilled or frozen product was exported to the EU, filling only two percent of the current quota. Additionally, over half of this chilled¹ product is bison, which represented as much as 99 percent of Canadian bovine meat exports to the EU in 2005 and 2006 (Global Trade Atlas, 2017). Therefore, little Canadian beef is currently entering the EU market. A possible contributing factor to producers' decisions to forego current export opportunities to the EU, in addition to the current 20 percent tariff, may be EU meat regulations. As the discussion to follow will elaborate upon, there exists a large disparity between Canadian and EU livestock production regulations, presenting non-tariff trade barriers to Canadian beef producers accessing the EU market.

¹ The data regarding frozen bovine meat was not disaggregated to show the proportion that is bison.

1.2.2 EU Ban on Growth Enhancing Technologies

Growth enhancing products (GEPs)² and their use for livestock production came into the EU's public spotlight in 1977. Concern for negative human health implications was growing in response to the discovery of several young Italian children showing symptoms typically associated with exposure to large doses of estrogen. A paper published shortly afterwards in *The Lancet* (Fara et al., 1979) suggested that the source of contamination could have been untested meat served at a cafeteria where the affected children attended school. Despite uncertainty regarding the cause, this incident triggered concern among some consumers for the safety of their domestic meat supply (Devereaux, 2006; Vogel, 1995).

The Italian school scare was followed by the publication of newspaper articles in 1980 which reported babies growing oversized genitals and breasts. These abnormalities were being linked to 30,000 jars of veal baby food which were discovered to contain high residue levels of dimethyl stilbenes (DES), a synthetic hormonal substance commonly administered to dairy cattle (Devereaux, 2006). The anxiety initiated by this incident, compounded with that of the Italian hormone scandal, sparked public outrage throughout Europe, placing considerable pressure on European Community Regulators to implement restrictions on the use of DES (Devereaux, 2006; Vogel, 1995).

Within a year the EU Council of Ministers voted to ban thyrostatic and stilbene hormonal substances, which include DES, through Directive 81/602/EEC (Vogel, 1995). Although DES residue was not proven to be the cause the infants' abnormal growth, it was already considered to be carcinogenic and illegal in other nations, so there existed justification for implementing a ban

² GEP refers to a pharmaceutical substance administered to livestock to improve their production efficiency. Their use in Canadian beef cattle will be elaborated upon in greater detail throughout section 1.2.3.

(Devereaux, 2006). However, the hormone ban did not end with DES, and the European Community also considered imposing a ban on other substances having estrogenic, androgenic or gestagenic actions, pending further investigation. The ban was delayed, as opposition by the British beef industry resulted in it being halted for further scientific inquiry to examine their safety (Vogel, 1995).

The EU commissioned study results concluded that naturally occurring steroid hormones, estradiol, testosterone, and progesterone, presented no risk to human health when used in livestock properly and with respect to maximum doses. Subsequent research also determined that the synthetic hormones, zeranol and trenbolone acetate were also not harmful to consumers (Vogel, 1995). Despite these conclusions, the EU ultimately adopted a ban on both synthetic and naturally-occurring hormone substances for non-therapeutic purposes in 1985, which went into effect in 1988. Essentially, use of all hormonal growth-promoting substances in production of meat or milk was made illegal for livestock producers in the EU at that time, with the ban being extended to imported meat from treated livestock in 1989 (Devereaux, 2006; Vogel, 1995). Shortly after, the ban on growth-promoting hormones was expanded to include beta-agonists as well, with the implementation of Directive 96/22/EC. However, the ban on beta-agonists preceded their commercialization so they were never widely used in the EU (Buchanan-Smith, 2016; Centner et al., 2014).

Consumer pressure was one of the most important drivers of the EU's ban on hormones and beta-agonists as anti-hormone sentiments spread during the 1980s. At that time, several consumer and environmental groups launched campaigns against hormone usage in meat production, making the issue more visible to consumers. Further, support to the cause was generated by a growing subset of consumers interested in purchasing natural foods. The strength

of the EU consumer movement made some member nations, which still allowed the use of at least one GEP, apprehensive to continue doing so and risk consumers viewing their meat products as inferior to nations that already banned them. Thus, opposition to the ban from member nations that had not yet implemented their own was weakening, which added support to the decision for an EU-wide ban (Vogel, 1995).

In addition to growing public concerns, the EU was facing financial pressure from rapidly increasing agricultural commodity stocks, especially beef and veal stocks. Between 1983 and 1984 stocks grew by 177 000 and 388 000 metric tonnes, respectively, each year (Commission of the European Communities, 1987). These rapidly growing stocks were causing problems for the European Agriculture Guidance and Guarantee Fund (EAGGF), and a solution was needed to keep stocks from continuing their rapid accumulation. Thus, a second incentive for banning the use of GEPs presented itself, as reducing their usage would cause the rate of domestic beef production to slow. Implementing a ban offered a politically palatable way to slow the growth of beef stocks and relieve some of the financial pressure being placed on the EAGGF (Peterson, 1989).

Finally, the European Union was facing a third source of pressure driving policy change, the need to create a harmonized veterinary policy across its member states. Prior to the ban, half of the member states had already banned hormonal substances for growth promotion, while the others still allowed at least some to be used. These disjointed policies created trade barriers within the EU's member nations, as regions that had implemented a ban did not allow meat imports from those that had not. To address these issues, steps toward uniformity in veterinary policies were already being undertaken by the EU prior to the hormone scandals. However, heightened public pressure made the need for policy reform in this area increasingly urgent.

Implementing a union-wide ban on all hormonal substances for growth promotion also presented itself as a politically favourable method of harmonizing veterinary standards among member nations and reducing trade barriers between them (Vogel, 1995).

As a result of the political situation at that time, the scientific conclusion that hormonal GEPs were safe to use in meat production did not prevent the EU from banning their use in all domestically produced and imported meat products. Since the hormone ban went into full effect in 1989, and later the ban on beta-agonists, their non-therapeutic use in the production of meat marketed within the EU has remained illegal. This presents a problem for Canadian producers that want to export to the EU as the use of GEPs is legal and common throughout North America (Canadian Animal Health Institute, 2003).

1.2.3 Growth Enhancing Technologies in Canadian Beef Production

GEPs have been a management tool available to beef producers since the 1950s. There are six hormone substances approved for use in Canada including estrogen, testosterone and progesterone, which are naturally occurring, and zeranol, melengestrol acetate and trenbolone acetate, which are synthetic (Canadian Animal Health Institute, 2003).³ These substances are administered as a small pellet implanted under the skin of the animal's ear, except for melengestrol acetate which is administered as a feed additive. The pellet form works by slowly releasing the hormone into the animal's bloodstream over a period of time. Once released into the bloodstream, these substances quickly bind to a specific receptor which stimulates the biological response. Shortly after, the liver metabolizes the compound and it is removed from the

³ Growth hormones supplement substances naturally produced by the animal. Hormones are present in all beef, as well as a variety of other foods, regardless of whether or not the animal it was derived from was treated (Canadian Animal Health Institute, 2003).

body (Johnson and Beckett, 2014). The purpose of implanting is to improve the average daily gain rate, increase feed intake and improve feeding efficiency, while also increasing lean muscle deposition (Johnson and Beckett, 2014; Reinhardt, 2007).

This management tool can be used at all production stages of the beef supply chain, including cow-calf, backgrounding and feedlot operations. However, its adoption rate varies between supply chain stages. In western Canada only 24 percent of cow-calf producers reported implanting their calves either prior to, or at weaning time (Western Beef Development Centre, 2015). Low adoption rates have also been observed among US cow-calf producers, where 10 percent of all producers reported implanting their calves. Operations with larger herds tend to adopt this technology to a larger degree, as 27 percent of herds with more than 200 cattle report use (Deblitz and Dhuyvetter, 2013). Low adoption rates for growth enhancing technology in the cow-calf sector can largely be attributed to the diversity between farms, which causes the pace of adoption to be slower than that of the more homogenous feedlot industry (Gaylean, Ponce and Schutz, 2011).

Adoption of implants among Canadian feedlot producers is higher than in the cow-calf sector (Campbell, Kenealy and Campbell, 2009). Although there are no recent studies which directly quantify the adoption rate of this practice in Canada, statistics exist from the US feedlot industry that indicate 90 percent of large feedlots use GEPs. Much like the cow-calf sector, smaller feedlot operations also tend to use this technology less frequently and the average adoption rate across all feedlot size categories falls to 79 percent (Deblitz and Dhuyvetter, 2013). The similarity of implant usage among cow-calf operations in Canada and the US suggests that there are also likely to be similar in adoption rates among feedlot operations in these respective

nations. Therefore, adoption of hormone implants is also likely more common in Canadian feedlots than cow calf operations (Gaylean, Ponce, Schutz, 2011).

β -adrenergic agonists (beta agonists) are a relatively newer technology for growth promotion in beef cattle. They became commercially available in Canada in 2004 (Buchanan-Smith, 2016). Although the EU has banned these substances for similar reasoning as that of hormone implants, they work much differently. Beta agonists are orally active, so they are added into the ration instead of being directly implanted under the skin, and are only used for the last 20 to 42 days the animal spends on feed. As a result of the timing of their administration, beta agonists are not used by cow-calf producers. The beta agonist binds to a receptor in the skeletal muscle, which stimulates the muscle cell to incorporate relatively greater levels of protein and water and also slows down the rate of muscle cell degradation. In addition to increasing the growth of muscle cells, beta agonists also work to slow the development of fat cells by decreasing the body's rate of building new fat cells and increasing the rate of breaking down existing ones. The result of administering these substances to a beef animal is increased production of lean meat (Johnson and Beckett, 2014).

Initially, there were two beta agonist substances commercially available to Canadian beef producers: ractopamine hydrochloride and zilpaterol hydrochloride. Although no specific estimates exist for Canadian adoption rates, in the US it was estimated that 53 percent of fed cattle received these pharmaceuticals (Deblitz and Dhuyvetter, 2013). However, observations of extreme lameness in cattle that had been fed with ractopamine triggered concerns with using this additive and prompted Merck to suspend sales (Huffstutter and Polansek, 2013; Smythe, 2014). These recently emerging concerns for use of beta agonists and potential animal welfare problems has led to a reduction in their usage (Smythe, 2014).

1.3 Exporting Canadian Beef to the EU

As many of the EU prohibited substances are commonly administered to Canadian cattle, beef exported to the EU must meet certain criteria to assure that the animals it was derived from were never administered prohibited substances. To provide these assurances, the Canadian Food Inspection Agency (CFIA) administers the ‘Canadian Program for Certifying Freedom from Growth Enhancing Products for the Export of Beef to the European Union’, which will be referred to as the ‘program’ throughout the text that follows. There are 10 key components of the program which producers must comply with for CFIA to grant them an export certificate⁴ to the EU:

- Animals to be exported must be identified under the Canadian livestock identification and traceability program. Therefore, they need to carry an approved identification tag that has a unique identifier. If the farm is mixed-status, meaning some animals may be implanted and sold into the other channels, the animals intended for EU export must have an alternate visual identifier in addition to the approved traceability program tag. These animals must easily be identified in a walk-through and marked prior to any handling where they may be implanted.
- Prior to leaving the farm of origin, the animal must be identified with an approved tag. If this tag is lost or revoked throughout the growing period, it can be replaced by a designated person at the farm or feedlot and documentation recording replaced tags must be kept.

⁴ Granting of an export certificate by CFIA means that beef derived from the enrolled animal is eligible to be imported by the EU.

- All animals in the program must originate at a registered farm or feedlot. Birth farms must be registered before the animal is transferred to another registered operation. Before the animal arrives, the feedlot or auction mart must also be registered.
- Inventory of animals in the program must be accurate and kept up to date.
- Animals in the program may only be transferred to farms or auction markets that are also registered to maintain their eligibility in the program.
- Traceability of the animals must be maintained throughout their life, from birth through the slaughter process. Transfer documentation has to be CFIA accepted and must be provided upon arrival at the slaughter facility.
- Animals must never be administered any growth enhancing products throughout their entire life.
- Farms in the program which use these products, or have them on the premises, must record their purchases and the use or disposal of them.
- Records identifying the ingredients in any mixed feeds or feed supplements, as well as their source, that are given to enrolled animals must be maintained.
- The required records must be made available to CFIA or EU Officials upon demand and maintained for at least three years for birth farms, and two years for feedlots and auction markets from the date the animals were received.

CFIA approved veterinarians will oversee adherence to these program components, and conduct on-site assessments at least once per year. Additionally, once the animals reach the EU approved processing facility, they will also be subjected to physical checks for implants and have samples taken to test for hormonal residue (CFIA, 2016).

1.4 Motivation and Objectives

Although signing the CETA will grant Canadian beef producers much desired access to the EU market, feasibility of this trade opportunity still needs evaluation. Starting with the first segment of the beef supply chain, cow-calf production, this thesis quantifies the economic impact that meeting EU beef production regulations would have on these farms. As EU certification is expected to increase production costs, the results of this research will offer an estimation of the price premium cow-calf producers must be offered to outweigh the costs while maintaining a normal profit.

The second motivation for this research is to estimate the supply of feeder calves in western Canada that could enter the EU channel at various premium levels. Once the CETA is fully enforced, 64 950 tonnes (carcass weight equivalent) of Canadian beef will be allowed to enter the EU without tariffs. To fill this quota, a minimum of approximately 157 000 certified fed cattle will need to be grown⁵. However, given that not all beef cuts may be exported to the EU, it is likely that a supply in excess of 157,000 cattle could be necessary (Duckworth, 2017a). As there is a large degree of heterogeneity amongst cow-calf producers and their practices, some producers are already in a relatively ‘more compliant’ position with respect to EU regulations than others (Western Beef Development Centre, 2015; Manglai, 2016). Therefore, compliance costs should be disaggregated and modelled to reflect these variations amongst producers. Segmenting cow-calf producers by their regular practices will allow the estimation of feeder calf supply within each group. The purpose of doing this is to determine the number of feeder calves

⁵ 64 950 tonne CWE, assuming 63% carcass yield from live weight (Holland, Loveday and Ferguson, 2014).
 $64\,950 \text{ tonne} / 0.63 = 103\,095 \text{ tonne} / 658 \text{ kg live weight (ACFA, n.d.)} = 156\,680 \text{ live cattle}$

that could be diverted into the EU marketing channel within each cost of compliance, or premium, category.

Essentially, the motivation of this thesis is to determine the minimum price required to fulfill the beef quota for CETA by western Canadian cow-calf producers. This serves the overall purpose of determining the feasibility of accessing the EU beef market for cow-calf producers in western Canada. Thus, the objectives of this thesis are as follows:

- Develop a model for estimating the cost of production for conventional production as well as EU certified production. This model will need the capability to simulate the impact of changing production practices on costs.
- Simulate the break-even cost of production for these various scenarios, comparison of which to the EU certified cost of production will provide an estimate of the price premium necessary to stimulate a supply response for filling the CETA beef quota.
- Estimate the supply of cattle available within each production category, as will be defined for cost of production simulations.

CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction

Research concerning beef production costs, the economic implications of removing growth enhancing technologies from the beef supply chain and systems dynamics modelling will be discussed in this literature review. First, conventional cow-calf and feedlot production economics in North America is discussed, with special attention being paid to the underlying drivers of costs in these industries. Immediately following the discussion on conventional production is literature that analyzes the impacts of alternative beef production strategies that include the removal of growth enhancing technologies. The literature covered in these first two sections sets the foundation for understanding production costs and how adjusting production for compliance with EU meat regulations could affect them. Finally, various applications of systems modelling methodology to beef production economics research are discussed, highlighting the wide variety of questions to which this method has been applied.

2.2 Cow-Calf Production

Throughout this paper, cow-calf production refers to farming or ranching operations that maintain a herd of brood cows for the purposes of raising and selling weaned calves. These farms make up the base of the beef supply chain, supplying the calves needed to be fed to slaughter weight and processed into beef products (MacLachlan, 2001). Traditionally, cow-calf production has exhibited the characteristics of a highly competitive market, including a large number of producers accompanied by many buyers, selling mostly homogenous products and publicly accessible price information. As a result of these market characteristics, conventional cow-calf producers are price-takers and can only exert control over the cost and output level

components of their farm's profitability (Perloff, 2014). Although much of the following literature concerns these determinants of overall profitability for cow-calf enterprises, the focus taken here is on the cost of production aspect of profits. Therefore, the following literature reviews the key drivers of production costs for cow-calf producers.

2.2.1 Feed

The costs associated with producing forages, either grazed or mechanically harvested, typically make up the largest portion of a cow-calf operation's cost of production. However, these costs can be highly variable between producers, as cattle can utilize a wide range of plant matter that contains cellulose, enabling them to digest forages in many different environments. As a result, variability in feed costs is largely driven by environmental factors that influence the available grazing resources and the necessity of harvesting and conserving forages (Short, 2001). Therefore, the region in which a producer is operating can have a large influence on their cost of production, evidence of which was highlighted by Short (2001) and Nehring et al. (2014).

Taylor and Field (1995) found that decreasing use of harvested forages and increasing the number of days grazing to be the most commonly identified cost reduction strategy amongst low cost producers in their survey. They found disparities in profit to be mostly driven by costs, with the difference being \$222 per head between low and high cost producers. The results of Ramsey et al.'s (2005) paper further supported the management strategies suggested by Taylor and Field (1995), where they also found that increasing use of harvested forage was associated with increased production costs. However, their results also indicated that increasing the use of harvested feed sources was not related to an increase in pounds weaned per female, which was unexpected. Both of these studies concluded that increased use of harvested forage is not expected to be offset by increased productivity and revenue, so the overall impact on profitability

is negative. Miller et al. (2001) estimated that 50 percent of cow-calf farm-to-farm variation in returns to labour and management was attributed to feed costs. Much like Short (2001), they also found some of the impact that feed costs have on profits to be a result of the high level of correlation between harvested feed and other costs. Harvesting and delivering feed mechanically is associated with increased expenses such as equipment investment, depreciation, capital charges, operating costs and labour. Essentially, herds that exhibit high feed costs tend to be high cost in other areas as well.

2.2.2 Economies of Size

‘Economies of size’ occur when the per-unit cost of production decreases as a firm increases its output. They can result from several advantages related to larger scale production, such as the ability to spread a fixed cost over more units of output, or the ability to adopt larger scale technologies that may reduce variable costs (Debertin, 1986). Cow-calf producers are not exempt from experiencing economies of size as some research has found a tendency for cow-calf operations to experience falling average costs as their cow herd increases. Langemeier, McGrann and Parker (1999) categorized operations included in their data set by cow herd size, finding that the 500-999 head category has the lowest production costs. When a similar data set was used to regress pre-tax cost per cow and percent return on assets on herd size, it was also found that increasing the number of cattle has a negative correlation to per unit costs (Ramsey et al., 2005). These results were echoed again in studies conducted on producers across all US regions as well as Saskatchewan producers, where production costs also declined with successively larger herd size categories (Leung, Kulshreshtha and Brown, 1991; Short, 2001).

Featherstone, Langemeier and Ismet (1997) and Jones (2000) suggested in both of their papers that larger herd sizes are related to improved production efficiency, offering an

explanation as to why economies of size are so often observed in this industry. Featherstone, Langemeier and Ismet (1997) found herd size to be positively related to technical and scale efficiency, which they proposed could be combined with allocative efficiency to represent overall efficiency for a farm. Jones' (2000) results predicted that overall efficiency increases for herd sizes up to 289 cattle, but subsequent gains in efficiency become small once the herd reaches and exceeds 185 cattle.

Despite the prevalence of economies of size being observed throughout the cow-calf production economics literature, some literature also suggests that there may be limits to how far economies of size can stretch. Ramsey et al. (2005) found that the per-unit costs of production declined at a decreasing rate as herd size increased, as was indicated by the positivity of their squared herd size variable coefficient. Leung, Kulshreshtha and Brown (1991) also found that their average total cost curve eventually went flat as the herd size increased. Langemeier, McGrann and Parker (1999) found evidence of per-unit production costs that actually begin to increase with herds in the 1000 or more head category, which suggests that diseconomies of size may exist in the cow-calf sector. Increasing costs as operation size grows was also seen in the dataset used by Jones (2000), where the minimum average cost frontier line drawn from the raw data shows an obvious minimum point with both larger and smaller producers displaying higher production costs. Although the literature finds that production costs tend to decline as herd size increases, there may be exceptions as well as evidence that improved management could play a larger role than herd size when it comes to profitability (Bredahl and Marks, 2012)

Some of the aforementioned studies also suggested that management may actually be a more important driver of costs than size. Langemeier, McGrann and Parker (1999) found ranches from every size category represented in each profitability quartile, while Leung, Kulshreshtha

and Brown (1991) noted that operations smaller than the estimated optimal size were capable of achieving up to 80 percent of their cost efficiency. Samarajeewa et al. (2012) found that small operations could actually exhibit higher efficiency levels than larger ones. They suggest that the optimal operation size may be determined by the resources available to each individual operation. These contradictory results were somewhat explained by Miller et al. (2001) where they conclude that cost advantages are available to smaller producers that carefully manage other production variables, adding support to the idea that managerial ability or effort may actually be the more important factor driving production costs.

Nehring et al. (2014) was the only study found which explicitly refuted the idea that economies of size are what causes larger operations to have lower costs. They used survey data from 1,964 cow-calf farm operations across all US regions. They did not find that the number of brood cows significantly explained variations in profitability, which was measured by the operating profit margin ratio. The important difference between Nehring et al (2014) and the other studies discussed is that their model included adoption rates for technology or advanced management practices which the others do not hold constant. The high level of correlation found between operation size and adoption rate offers some explanation as to why other studies find herd size to be an important driver of production costs, perhaps falsely concluding that economies of size are the cause.

Overall, the literature is inconsistent on its conclusions regarding herd size and profitability. Exceptions to economies of size were noted in much of the literature discussed, therefore it cannot be concluded that large herds have absolute cost advantages over their smaller competitors. Rather, management is perhaps the underlying driver of production costs in the cow-calf industry.

2.2.3 Biological Performance

When examining the factors which drive variability in profits between cow-calf producers, production costs are frequently found to be more important than production performance. In other words, calf weight, weaning percentage, calving percentage or pounds weaned per cow are not found to be significantly related to profitability when production costs are controlled for (Miller et al., 2001; Taylor and Field, 1995). However, biological performance can be an important driver of production costs, so literature which concerns the relationship between production performance and costs is discussed in this section.

Short's (2001) analysis of cow-calf producers across all US regions offers insight in to why higher production performance does not seem to be correlated with improved profitability. Short (2001) unexpectedly found that higher weaning weights and calf crop percentages were more frequently observed among high cost producers, which could be a result of the correlation between production costs and regions. Producers that operate in climates with cold winters need to harvest more forages, adding to their costs, while also needing to plan their calving seasons around favourable weather. This is why tighter calving distributions and higher weights tend to be correlated with cooler regions, whereas producers in warmer regions do not need a set calving window while also enjoying lower production costs because they can graze for longer periods. Therefore, when analyzing the impact that biological performance has on profitability or costs, it is important to take region into account, as environment can simultaneously affect both biological performance and production costs, potentially causing a spurious correlation problem if not held constant.

Ramsey et al. (2005) found biological production performance measurements were significantly related to several measures of operation performance, which include economic

production cost per cow. Calving percentage, death losses and shortened breeding season were all found to be significantly related to decreasing costs. Similar conclusions were also reached by Samarejeewa et al. (2012), who found that calving, conception and weaning rates were all significant factors in their model for economic efficiency. Both of these studies emphasized how allocating management effort to maintaining live, healthy calves is an important strategy for improving firm performance.

It should be noted that Short's (2001) paper used data from across all US regions, whereas Ramsey et al. (2005) and Samarejeewa et al. (2012) used data from smaller areas, Texas, Oklahoma and New Mexico, and Alberta, respectively. Therefore, some rationale for their contradictory results can be offered. Short (2001) found that climate was an important driver of production costs, while biological performance was also largely driven by environment. The data set used by Short (2001) would have contained a large degree of climatic variation. The other two studies used data sets where there would be little climatic variation between producers, so variations in economic efficiency between them could be attributed to differences in biological performance between herds to a larger degree.

2.3 Economics of Alternative Beef Production Systems

The literature review up to here covered the costs associated with conventional beef production. However, concerns regarding conventional practices have resulted in a growing consumer segment that demands alternative production process attributes in their beef products (Capper and Hayes, 2012). In a response to the potential for earning price premiums over generic beef marketing strategies, producers have begun adopting alternative management systems so they can compete in these growing niche markets (Roberts, Spurgeon and Fowler, 2007). Micheels and Gow (2012) suggest that beef producers which take a market-oriented focus on

their operation, by offering a product with the attributes their down-stream buyers demand, tend to rate their performance more highly. Interestingly, their results also indicate that taking a cost-focus was not related to improved firm performance, which contradicts many findings throughout the previously discussed conventional production economics literature. Thus, shifting away from traditional generic beef production strategies and moving towards niche marketing may provide opportunities for beef producers to improve the profitability of their operations despite the potential for increased production costs (Hughes, 2000).

The growing tendency for beef producers to take on alternative management systems in response to niche marketing opportunities, such as organic or artificial-hormone free, has prompted the study of these practices and their implications. The economic, social and environmental outcomes that the following studies measure can be highly related, as the reduction of resource usage or an increase in production can correlate with an increase in economic returns (Capper and Hayes, 2012). Therefore, the following literature surveyed will include North American studies which entail measurement of economic, environmental or productivity impacts associated with alternative beef production relative to conventional systems.

Fernandez and Woodward (1999) were among the first studies to explicitly quantify the performance and economic implications associated with alternative livestock production systems. They experimented with calves raised under conventional or organic systems, which were then randomly assigned to an organic or conventional finishing phase treatment. Experimental data on the performance of cattle under these 4 different production systems (conventional cow-calf as well as feedlot, conventional cow-calf and organic feedlot, organic cow-calf and conventional feedlot, and organic cow-calf as well as feedlot) was used. Their cost

analysis of both finishing phase regimes found that the cost of finishing steers organically is 39 percent higher than conventionally.

Coopriider et al. (2011) extended upon Fernandez and Woodward's (1999) research by gathering social and environmental sustainability measures, in addition to economic measures, using experimental data. Although Coopriider et al. (2011) focused only on the finishing phase of production, their results also indicated that conventional production practices result in the highest production performance and lowest production costs. They also found that conventional production is associated with relatively fewer carbon emissions than the low-input control group, which was a proxy for organic practices. However, when they examined the social sustainability aspect of beef production, they found that the organic-proxy group typically had higher marbling and tenderness scores while also meeting consumer demand for naturally raised beef, traits which also can positively influence economic outcomes. They concluded that no single feedlot production system satisfied all three measures of sustainability, although both systems did have sustainability merits associated with them.

Capper (2012) also examined the environmental impacts of conventional, natural and grass-fed⁶ beef production using a systems modelling methodology. The environmental outcomes were modelled using a deterministic whole-system model based on ruminant nutrition and metabolism. Resource inputs and waste outputs of each system were calculated for all stages of production annually. Their results indicated that natural and grass-fed production requires more animals, land, water and fossil fuels to produce the same amount of beef. This paper

⁶ In Capper (2012), the 'natural' system is identical to that of typical beef production practices, except for the use of GEPs. In their paper, 'natural' meant the cattle were never administered GEPs. They defined the 'grass fed' system as one in which the cattle are fed a forage only diet from birth to slaughter, never being fed grain or other non-forage supplementation.

concluded that grass-fed beef has the largest carbon foot-print ($26,785 \times 10^3$ t), followed by natural beef ($18,772 \times 10^3$ t) and conventional beef has the smallest foot-print ($15,989 \times 10^3$ t).

Environmental and economic impacts are related to one another, as increasing resource inputs into a production system can often mean that the economic costs of that production system are also rising. Capper and Hayes (2012) showed this relationship in their extension of Capper's (2012) environmental model, by calculating the additional economic cost that producing beef in the absence of growth enhancing technologies would place on the industry. Estimation of the inputs required under each system to maintain a beef production level of 454 million kilograms per year were quantified and compared to determine the impacts of removing growth enhancing technologies. Higher nutrient requirements, coupled with reduced slaughter weight and dressing percentage, means that the US would need to increase its national cattle population by 385,000 animals to maintain beef production. The additional requirements for feedstuffs, grazing lands and water would be 2,830,000 tonnes, 265,000 hectares, and $20,139 \times 10^6$ litres, respectively. The economic burden that removal of these technologies on the industry is estimated to be equivalent to a tax of 8.2 percent on beef production.

Lawrence and Ibarburu (2007) estimate the farm, as well as national, level impacts of removing common pharmaceutical technologies from beef production. The pharmaceuticals in question cover a larger scope than the previously discussed papers, as they also included ionophores, sub-therapeutic antibiotics and parasite control in addition to hormone implants and beta-agonists. For each technology, they conducted a meta-analysis and used the results as parameters to adjust regional cost of production budgets to reflect the impact their removal would have on a farm level. Then, these farm level economic effects were scaled using adoption rates and regional herd sizes to model the nation-wide impact of removing pharmaceuticals from

beef production. They estimated the economic effect of removing these technologies entirely was an addition of \$365 per head to cost of production over the animal's entire lifetime, as well as a reduction in the amount of beef produced despite no change in inventory. Ultimately, US consumers would be paying a higher price and importing more beef, while several producers and resources would be forced out of beef production.

Using a partial equilibrium model, Olvera (2016) estimated the potential impacts of removing feed-grade antibiotics for growth promotion as well as removal of all growth-enhancing technologies from the US beef industry. Much like Lawrence and Ibarburu (2007), Olvera (2016) also took an economic focus in their quantification of the impact that removing these technologies could have on production and consumption. Their results suggest that removal of feed grade antibiotics alone could result in a 270,000 head reduction in cattle inventories and 227.3 million pound reduction in carcass beef in the year following a ban, while consumption and inventory were estimated to decrease by 1 percent five years post-ban. Unsurprisingly, their model predicted that the removal of all growth enhancing technologies would have larger ramifications for the industry, suggesting a 3.1 million head decline in cattle inventories and a 2.2 billion pound reduction in carcass beef just in the first year that follows a ban. Their longer-term predictions estimate a 10.5 percent decline in production and an 8.2 percent decline in consumption with a 9.1 percent increase in imports.

2.4 Systems Modelling and Beef Production Economics

Systems modelling, or simulation modelling, is a method of organizing data and mathematical approximations of relationships between variables to mimic real world processes. This methodology is popular in beef research as it enables risk-free simulation of various scenarios and outcomes without costly live subject experimentation (Ruth and Hannon, 1997;

Mayer, 2002). The earliest applications of systems modelling to beef enterprise profitability employed linear programming models. Basically, these studies specified an objective function by combining existing numerical estimates for various relationships or rates associated with livestock production and optimized it subject to the constraints faced by the hypothetical enterprise, such as climate or budget.

Woodworth (1973) and D'Aquino (1974) used this type of modelling to optimize the net returns to an operation by strategically allocating grazing resources. As there are varying productivity levels and production costs associated with differing rangelands, these studies were able to estimate an optimum allocation pattern for utilizing them. However, these models fell short when looking at more than one period because of their static specification. In an extension of D'Aquino's (1974) range resource allocation model, Bartlett, Evans and Bement (1974) used discrete continuity variables to allow their model to incorporate the flow of range resources from season to season to develop a ranch management plan by optimizing net return. Whitson (1975) suggested that the models previously proposed may not have reached a true optimal solution because these models did not account for the trade-off between risk and increasing returns, which are important to the modelling of managerial behaviour. Therefore, Whitson (1975) improved upon what he calls the 'traditional' economic analysis of ranch management by incorporating risk and uncertainty, which was made possible by quadratic programming methods which had previously been applied in investment analysis.

Following linear programming models was the rise of computers, applications of which have enabled systems modelling to incorporate more variables and become a widely-applied research tool in many fields of study, such as physical sciences, engineering and biology, as well as the social sciences (Koong, Baldwin and Ulyatt, 1978). Unsurprisingly, the field of animal

sciences has adopted systems modelling tools to approach many of the research questions which they face. Generally in this field these models simulate cause and effect relationships, such as the phenotype of an offspring as a function of the phenotype of its parents, the nutritional requirements of an animals as a function of its size, or the value of a carcass as a function of its measurements. However the advantage to using systems modelling for simulating these relationships is that they enable the user to see the impact on several aspects of performance, rather than only measuring one outcome as was the case with linear programming optimization techniques (Joandet and Cartwright, 1975).

Application of computer programing has resulted in the development of several general system models for beef cattle production, which have been applied to many production economics research questions. Basically, these models use equations to imitate biological processes involved in the production of beef cattle so that the outcomes of altering management decisions can be simulated without needing to experiment. In the following discussion, some economic applications of systems modelling methodology to cattle production research are described.

One of the most commonly cited models is Texas A&M University's (TAMU) Cattle Production Systems Model (Sanders, 1977; Sanders and Cartwright, 1979a; Sanders and Cartwright 1979b), which simulates individual cattle production performance in response to a variety of pre-determined factors. The performance of cattle with varying genotypes under alternative management strategies and environmental conditions, such as breeding season length, market timing strategies, supplementation programs or feed resources can simulated. Herd production models preceding this one typically specified a level of cattle performance and simulated the required feed inputs to achieve it. The TAMU model is novel in its ability to

simulate the more realistic problem of maximizing cattle production given the environment or feed resource constraints faced by the manager.

As a result of its flexibility, the TAMU model has been modified several times and applied to a large variety of research questions. Notter et al. (1979) adapted this model to be representative of a cow-calf-feedlot enterprise in the Midwest of the United States. Using the adapted model, they simulated the effects of varying milk production across different cattle types on biological productivity and economic efficiency. The results for varying body sizes and their subsequent effect on nutrition costs concluded that the optimum milking level depends on feed prices.

Doren et al. (1984) simulated the production outcomes of varying management alternatives and evaluated the economic impacts associated with them. Simulated were varying calving times (winter, spring or split season), levels of winter supplementation, and age of the dam at her first calving (two or three years). The corresponding net returns were simulated for each alternative, which enabled the researchers to weigh the production benefits as well as the costs for these varying management strategies, finding that increasing production levels does not always result in increased returns.

Stokes, Farris and Cartwright (1981), using the TAMU model as a biological basis, developed an economic model that could extend beyond the traditional cow-calf production paradigm to also simulate retained ownership of weaned calves. Therefore, in addition to simulating differing cow types, with a range of mature sizes and milk yield potentials, they also simulated varying ownership retention strategies such as selling weaned calves or retaining them through the backgrounder and/or feeding stages. The development of an economic model enabled them to determine the most profitable strategy over seven calf crops.

Another economic extension of the TAMU model by Angirasa, Shumway and Cartwright (1985), simulated production under a variety of forage and management systems. However, the original systems model focused on simulating animal performance given a forage resources base, which means the model could identify several forage alternatives as equivalent in achieving a level of cattle performance. To determine the least-cost feed alternative to achieve some level of performance for a given herd size, a complementary linear programming model was also included. In this approach, net returns were calculated and used to compare the economic efficiency of varying management practices so they could identify an optimal stocking density given the forage resource constraint.

Because the Texas model was developed to describe the flow of forage resources into cattle production, it can be scaled down to effectively model the typical small-holder herds seen in developing countries as well. This was the adaptation made by Kahn (1982), which incorporated many of the underlying principles of the TAMU model (Kahn, 1982; Kahn and Spedding 1983). However, there are some notable differences, such as calibrating the model to calculate animal performance on an individual basis rather than average for a class of animals within the larger herd, the stochastic treatment of events, smaller time-step integration that can be set for one to thirty days, and the ability to change output options so that day-to-day or multiple year performance can be simulated. They also included additional management options, such as the use of animals for draught power, to better represent the options available to managers in developing regions. The Kahn model has since been applied, under a variety of conditions, to simulate production outcomes such as reproductive performance (Kahn and Lerner, 1984) or voluntary dry matter intake (Kahn and Spedding, 1984).

The Kentucky BEEF (Beef, Energy and Economic evaluation for Farms) model (Loewer et al., 1980; Loewer et al., 1981) represents another application of systems modelling to beef cattle production, which is similar to the TAMU model in its ability to simulate production outcomes in response to differing enterprise management decisions. However, the Kentucky BEEF model covers a wider scope of responses to management decisions by including the interactions of growing crops, energy utilization and economics, in addition to cattle production, and has the flexibility to model cropping only. The large scope of alternatives that can be simulated makes the Kentucky BEEF model more applicable to mixed farming than that of TAMU's. However, the higher level of detail, specifically concerning beef production included in the TAMU model, makes it more widely-applied to beef production applications than the Kentucky BEEF model.

Another approach to simulating beef cattle production as a component of a whole-farm system, similar to the Kentucky BEEF model, was developed by Rotz, Buckmaster and Comerford (2005). In this contribution, a beef herd sub-model was integrated with other farm components, including crop growth, feeding, grazing and manure handling to form the 'Integrated Farm Management Model'. This model was developed so that long term performance, economic and environmental impacts of farm production systems can be simulated and compared. Although several other systems models can predict production and economic performance outcomes, this approach is novel in the simulation of environmental outcomes in response to nutrition management.

The Alberta Beef Production Simulation System (ABPSS) model developed by Pang (1997) focuses on the cattle enterprise rather than incorporating it into a sub-model as part of a whole-farm system. Similar to the TAMU model, the ABPSS model has the flexibility to

simulate the impacts of several different management strategies on productivity and economic outcomes. Included are four sub-models: Herd Inventory, which simulates the age distribution of the herd over time, Nutrient Requirements, which simulates what each animal in the herd needs to consume based on their physiological state, Forage Production, which simulates forage production and stocking rates based on soil zone, and Economics, which simulates returns from the management decisions input into the model.

The ABPSS model was applied to simulate the effect of cow size and milk production on a herd's economic efficiency. The model was calibrated to allow the user to vary the type of cattle, which affected other parts of the production system such as milk yield, calf growth rates and the nutrient requirements of both. By running simulations for small, medium and large size cows, with low, medium and high milk yield, the authors were able to predict which breed types were the most economically efficient. The analysis was taken further by varying the calf prices received, which affected the relative profitability associated with each cow type (Pang, 1997; Pang, Makarechian and Basarab, 1999). Although the detail and flexibility of the ABPSS model is similar to that of TAMU, the ABPSS model was created on a PC computer using 'Stella', a more user-friendly program (Pang, Makarechian and Basarab, 1999).

Tess and Kolstad (2000a, 2000b) developed a general cow-calf production system model with the ability to simulate the production performance of different cattle genotypes, as well as economic performance of the system in response to varying management strategies. Their research, which originated at Montana State University, was concerned with the Northern Great Plains and Rocky Mountain West production climate. The primary purpose was to simulate animal performance and system responses to changes in forage, genotype, animals' age, physiological state, and management strategies. However, it is also capable of incorporating the

costs of the model inputs and the revenue to be generated by the production output, allowing it to serve a dual purpose in simulating economic performance in response to varying management and production factors.

Reisenauer-Leesburg, Tess and Griffith (2007) parameterized Tess and Kolstad's model to estimate the effect of calving season timing and varying retained calf ownership strategies on a hypothetical ranch's gross margin. While Pang (1997) measured economic performance on a per-cow basis in their economic sub-model, Reisenauer-Leesburg, Tess and Griffith (2007) evaluated the economic performance of the ranch enterprise as a whole. This application was also novel in its evaluation of how returns vary in response to management strategies applied over the course of a cattle price cycle. Their results indicated that there isn't a single calving season or ownership retention strategy that is profitable in all points of the cycle. They concluded that the optimal management strategy is highly dependent on the current point in the cattle cycle.

Some systems models have been developed to address a specific research question, rather than applying one of the generalized models previously described. For example, Turner et al. (2013) developed a Stella model using actual production data from a 12,000 cow ranch in Nebraska for the purpose of simulating marketing decisions regarding cow sales. Their objective was to analyze the outcomes of three cow marketing scenarios (sale of 10 percent, 20 percent or 30 percent of the total cow herd) on net income and return on investment, and determine if the same marketing decisions would be made when using different measures of profitability. Their model included cowherd, replacement heifer and financial components which were simulated subject to a carrying capacity constraint. By using average per-head prices, sale weights did not have to be simulated in order to calculate returns, which made the model more concise and focused on simulating cow marketing decisions alone.

Another specific application of systems modelling by Rashford, Foulke and Taylor (2010) developed a simulation model for a typical cow-calf operation in western Wyoming. Their objective was to simulate how predatory pressure, and its impact on death loss, weaning weights, and variable costs, affects profitability. To model these effects, they adjusted parameters in the model to mimic predator pressure and determined whether increased death loss, decreased weaning weights or increased variable costs had the largest impacts on profits. The results suggested that increased death loss and decreased weights affected profits to a greater degree than increasing variable costs, which implies that increasing labour to reduce predation may be an efficient strategy.

Rich, Perry and Kaitibie (2009) used a systems modelling methodology to develop a cost-benefit model to determine the economic feasibility of implementing a sanitary certification system for Ethiopian beef exports. By simulating the proposed two-phase quarantine and feedlot system, animals which make it through are certified as disease-free and ready for slaughter, the authors could analyze the costs this system would place on exporters. The results suggested that the cost of compliance would not make the system unfeasible, but rather they found that the domestic input costs would constrain the competitiveness of Ethiopian beef exports.

2.5 Summary

The research objectives described in Chapter 1 require knowledge of cattle production economics, how production is affected by alternative production programs, and systems dynamics methodology. Thus, the selection of literature surveyed here provides an overview of the work already done in these fields. The literature on cow-calf production economics mainly focused on the drivers of production costs and what factors can influence them. As access to the

CETA quota may require producers to alter their production practices, literature regarding the economic impacts of alternative beef production systems was also surveyed to provide insight on the potential impacts of producing EU compliant cattle. In selecting the literature for alternative beef production system economics, a focus on production systems that constrain the use of pharmaceuticals was taken as compliance with EU regulations will not allow growth enhancing products to be used. Finally, examples for systems modelling of beef production economics were discussed to demonstrate the large range of potential applications for this method has for this area of research.

The literature reviewed throughout Chapter 2 serves as a foundation for building the conceptual model in Chapter 3. Information on the drivers of production costs for cow-calf operations is used to determine the factors which need to be included in the conceptual model. Part 2.3 of this literature review, regarding the economics of beef production in the absence of certain pharmaceuticals, offers insights into the factors that will be affected by foregoing the use of GEPs. These relationships will be simulated using a systems dynamics methodology, examples of which were surveyed in part 2.4 of this chapter. Thus, this chapter provides important information for constructing a conceptual model in Chapter 3.

CHAPTER 3 - CONCEPTUAL FRAMEWORK

3.1 Introduction

Described throughout this chapter is the conceptual framework by which a model that simulates the impact that meeting EU certification for importing has on profitability. The EU program described in Chapter 1 places constraints on the management practices that producers may employ on their operations, limiting their ability to maximize profit. Therefore, producing certified calves is expected to increase overall production costs and decrease productivity, which provides a disincentive for cow-calf producers to enroll in the program. To overcome this disincentive, cow-calf producers will need to be offered an adequate premium to outweigh the costs of enrollment (Brocklebank, 2004).

To better understand the impact of producing EU compliant calves, this chapter explores the interaction between the elements of compliance and drivers of profitability. The impact on these drivers is then related to overall profitability through the conceptual relationship between the drivers and profit itself. Essentially, this chapter maps out the relationship between the elements of the program and profitability, providing a foundation on which the working model is built.

3.2 Procuring EU Compliant Calves

Procuring a supply of beef calves grown under EU specifications will require adequate participation of cow-calf producers in the CFIA program for certifying beef free from growth enhancing products. As the first segment of the supply chain, filling the CETA beef quota is contingent on their willingness to participate in this alternative marketing channel by meeting the

necessary requirements. Given that 2015 Canadian bovine meat exports to the EU totalled only 326 tonnes, over half of which is bison, it is clear that the participation of more beef producers will be needed if the CETA tariff-free beef quota is to be utilized (Global Trade Atlas, 2017). However, increased labour burden and reduced productivity makes the cost of production for the EU channel greater than conventional ones. These additional costs are a result of the requirements for enrolling in the CFIA program, as producers must expend greater labour effort on identification and record keeping for their cattle and forego the use of GEPs which reduces productivity. Therefore, producers will be faced with a decision to balance the additional costs of enrolling calves in this program with the benefits they expect to receive from having access to this alternative marketing channel.

3.2.1 Profit Incentive

When cow-calf producers make the decision to participate in alternative marketing programs, which call for additional production attributes that conventional channels do not require, there can be several factors that influence their decision. For example, some studies have shown that cow-calf producers who switch to organic production tend to have relatively greater environmental and ethical concerns than their conventionally producing counter-parts (Lapple and Kelley, 2013; McEachern and Willock, 2007; Roberts, Spurgeon and Fowler, 2007; Wiegel, 2009). Brocklebank (2004) found that improved access to information is perceived as a benefit to participating in increased supply chain coordination initiatives. However, profitability was consistently found to play a role in the aforementioned studies, as well as other perceived benefits.

Profit is an important motivator for cow-calf producers to make changes of any nature to their regular production practices. Biswas et al. (1984) found that the behaviour of ranchers tends to conform to the rules of profit maximization, and subsequent research has further indicated that profit incentives are an important factor in their decision making process. Profitability was found to be the most common reason cited for adoption of new technologies (Joseph, 2013), and the most important factor influencing the decision to retain ownership of calves through backgrounding (Popp, Faminow and Parsch, 1999). Ochieng (2015) found that the top incentives for enticing producers to use an E.coli vaccine were related to profit, whether that be related to buyers' requirements, a subsidy to offset the costs, or an adequate premium paid. Additionally, Brocklebank (2004) concluded that the premium must outweigh the additional costs incurred to produce beef with different attributes in order to stimulate participation in branded beef programs. Thus, measuring profitability implications for enrolling in the EU hormone-free beef program is the approach taken in this thesis for evaluating the opportunity that the CETA presents to cow-calf producers in western Canada. The assumption will be made, as motivated by the aforementioned literature, that producers would be willing to enroll in the EU program only if the benefits of doing so would outweigh the increased production costs.

3.2.2 Accessing the EU Supply Chain

The remainder of this chapter will focus on the relationship between compliance with the EU marketing channel requirements and drivers of production costs for cow-calf producers. It should be noted that access to downstream buyers of EU certified cattle is also an important consideration, even though this factor will not be explicitly quantified for this analysis. Producing compliant cattle for exporting beef to the EU requires commitment from producers

early on in the production cycle, as the animals must be raised by EU protocols from birth onwards. Although they would still have the option to sell into the conventional, domestic marketing channel, it is unlikely that these buyers would offer a premium for EU certification and the producer would have taken on additional costs for nothing. This means that producers will need some assurance that they will have a buyer willing to compensate them for taking on the additional costs associated with raising cattle by EU protocol.

Cow-calf producers are not the only EU supply chain participants that face constraints on the practices they are allowed to follow for maintaining certified status. The next stage of the supply chain, feedlots, have to follow similar protocols to assure the cattle were never administered GEPs. Even further down the supply chain at the processor level, firms must also follow certain criteria to gain EU certification which can present additional costs (CFIA, 2016). All stages of the Canadian beef supply chain face barriers to entry for the EU market, which may be overcome if the firm is willing to take on the additional costs associated with following compliance protocol. Therefore, some level of commitment is required prior to the actual sale of the cattle or beef, as these compliance requirements can take time to fulfill like they do for the cow-calf producers.

These hurdles to entering the EU market mean that the other beef supply chain actors will need to take on additional transaction costs as well. In the case of the feedlot firms, they will need to find a buyer willing to compensate them for incurring additional production costs associated with compliance as the cow-calf producers do. However, they face an additional problem related to the sourcing of EU certified feeder calves. A similar situation arises for the processors, where they need to find adequate supplies of EU compliant fed cattle to fill their EU

designated processing runs. Processors also face risks related to accessing EU quota, depending on the allocation scheme that may be used. All of these issues present additional transaction costs for Canadian firms that intend to enter the EU beef market. Firstly, procuring EU compliant beef cattle through the spot market is very difficult, if at all possible, and would involve very large search costs. As an alternative, closer coordination between producers and processors can be arranged. However, this strategy for accessing adequate buyers or sellers of EU complaint cattle is not without costs for seeking out these particular firms, arranging contracts with them, determining their reputations and enforcing their contract obligations (Brocklebank et al., 2008).

For cow-calf producers currently participating in the EU marketing channel, a contractual arrangement is typically in place. Feedlot operations intending to enter the EU channel often seek out a cow-calf producer to supply certified calves under contract, or they may operate their own cow-calf herd (Faintuck, 2017; Fenton, 2017; Hagel, 2017; Kostelansky, 2017). This is unsurprising, given the commitment and investment each stage of the supply chain must make to enter the EU channel and the high risk of trying to procure these niche products in the spot market. Firms that attempt to enter the EU market without any arrangements in place may be unable to find suppliers or buyers of complaint cattle at short notice, making their investment in becoming compliant less likely to reap niche market premiums. Therefore, it is assumed here that cow-calf firms enrolling in the program will have some sort of contract or arrangement in place for sale of their EU certified calves. As a result, there is assumed to be no risk for these producers that they will invest additional resources in producing EU compliant calves and be subsequently unable to find a buyer that offers a premium for this attribute, forcing them to sell at the spot market price.

3.3 Measuring Profit Incentive

As profit is such an important factor in the decision making process of cow-calf producers, it is assumed here to be the primary incentive for producers' participation in the program. It could also be considered that the additional production costs associated with compliance presents a barrier to producers' participating in the program, and that the profit benefit must outweigh the extra costs before this barrier can be overcome. Once the required profit is attainable, perhaps some other factors may further influence which producers actually enroll (Brocklebank, 2004).

Profitability is defined as the difference between revenue earned from the sale of product, weaned calves in this case, and the expenses incurred for their production (Debertin, 2012). It can be further defined by Equation 1;

$$\textit{Profit} = (\textit{Price} * \textit{Quantity Produced}) - \textit{Total Production Costs} \quad (1)$$

The equation for profit consists of three main parts; *price* which refers to the price received for weaned calves, the *quantity produced*, and the *total production costs* incurred for producing them. The first component of the equation requires price information for Canadian beef going into the EU marketing channel once CETA is in effect. However, reliable modelling of this component is not possible at this time as the majority of current quota is being filled by bison (Global Trade Atlas, 2017). Additionally, the implementation of CETA could result in different prices for Canadian beef in the EU market once the tariff is removed. Therefore, estimating the revenue to be earned from enrolling in this program post-CETA implementation will be

unreliable given current information. These issues will make measuring profitability in the form presented by Equation 1 inappropriate.

An alternative way to measure the effect of EU compliance on the profitability of cow-calf producers without complete revenue information is to calculate the revenue required to cover production costs, including reinvestment in the firm. This measure, referred to as break-even (BE), is a metric which calculates the unit price required by the producer to cover these costs. These costs may include only direct costs, or they may also include a normal profit that gets directly reinvested in the firm. For the latter case, these reinvested funds are considered a cost. Either way, the BE for the enterprise is equivalent to the unit price of production which yields a zero profit. It can be derived by setting the profit equation to zero and rearranging to yield Equation 2;

$$\text{Value of Production (BE)} = \text{Production Costs} / \text{Quantity Produced} \quad (2)$$

Break-even (BE) price is the metric which will be used for quantifying the impact that EU compliance has on the cow-calf enterprise's profitability and will be calculated on a 'Canadian dollars per pounds weaned' basis. It is advantageous to use BE as a metric because its calculation involves both total costs and total output, so changes to either of these factors will influence its outcome. For making economic comparisons between different production processes, both of these factors are expected to be affected by the adjustments required of producers to access the EU beef quota. Furthermore, cow-calf producers can actually exercise control over these factors, whereas their ability to influence prices is very limited. Therefore, using BE allows more accurate measurement of the changes to costs associated with achieving certification than would a simple total cost measurement.

3.3.1 Drivers of Break Even Price

As can be seen in Equation 2, BE price consists of two factors: total costs of production and the total quantity produced. These factors are further broken-down into sub-components, as the profitability of the cow-calf enterprise can be influenced by several elements, some of which were elaborated upon in Chapter 2. The most important or influential drivers of production costs and productivity were discussed in the literature review, but this was far from a comprehensive list of all components. Furthermore, the factors described in the literature review were not presented exclusively in the context of western Canadian beef production, which is the region of focus for this research. Thus, additional discussion of the smaller components that will be key in building of a BE model for western Canadian cow-calf operations is warranted.

The total cost of production may be broken down into three categories, as defined by Larson (2013); direct costs, yardage costs and other costs. Although provincial cost of production budgets for western Canada may organize the expenses within these categories differently, typically the same items are included in the budget as a whole (AAF, 2016; Manitoba Agriculture, Food and Rural Initiatives, 2010). Direct costs can be thought of as the expenses related directly to the maintenance and health of the cattle. This includes expense categories such as feed and bedding, veterinarian services and pharmaceuticals, mineral supplements and breeding costs. Additionally, the total cost of this category is directly determined by the number of cattle in the herd, making them true variable costs. Although this is still somewhat the case for yardage costs, the relationship between herd size and total cost is not as direct. Yardage costs include the fixed costs of the operation, such as equipment and facilities, and the variable costs associated with them. These would include expenses such as fuel and repairs, utilities, and

labour, both paid and unpaid (Schoepp, 2011). Finally, costs, such as interest payments, trucking and marketing costs make up the 'other' third category.

Total production refers to the quantity of weaned beef calves that are available for sale at the end of the growing season. This measure can be expressed in total pounds, which is calculated by multiplying the number of weaned calves by their average live weight at sale time. The number of calves for sale is determined by the number of brood cows in the herd. However biological performance levels, of both the cows and calves, influences the actual output at the end of the season. Calving percentage, the portion of live calves born of all the bred cows, and death loss, the proportion of calves that do not survive to weaning time, are the key determinants of the number of calves weaned at the end of the season. The weights of these calves are mostly determined by their growth rates, often expressed as the average number of pounds gained per day, or average daily gain (ADG). ADG itself can be influenced by many factors such as the milk yield of the dam, breed, body type or forage quality (Sanders, 1977; Pang, 1997). Thus, output of cow-calf firms may be influenced by many factors beyond the number of cows producing calves.

Although total cost and production output are separate variables, some of their determinants are shared. The number of brood cows in the herd is an obvious example of this over-lap, as this value drives variable costs and can determine the influence of economies of size as well as total output. Growth rates, which influence the amount of feed required by the cow-calf pair as well as the total pounds of weaned calf, is another case in which a single variable can influence these measure simultaneously (Sanders, 1977; Pang, 1997). The existence of these interactions between different variables and their influence on measures of profitability can make

the process of building a model to predict the effect of EU compliance on BE complicated.

Therefore, deterministic systems modelling strategies will be employed for development of this model, so that these interactions can be conceptually mapped out to ensure they are properly represented in the model and their whole influence on the BE measure is parameterized.

3.4 Model Development

The BE for western Canadian cow-calf operations will be simulated using a deterministic systems modelling approach. As the literature covered in the previous chapter indicated, systems modelling provides a method by which beef production processes can be mimicked, then variables can be manipulated to simulate various outcomes (Ruth and Hannon, 1997; Mayer, 2002). An advantage of using a systems dynamics model is the ability to conceptually lay out the interactions of the variables, in addition to running simulations. This is because each variable must either be defined by a parameter if it is a boundary variable, meaning the system does not extend beyond it, or an equation if it interacts with others.

First, the BE variable and its components will be mapped out. Break even, as defined by Equation 2, is directly determined by total production costs and total output. In Figure 3.1, these three variables and the direction of their effects on one another, as indicated by the arrows, are mapped.

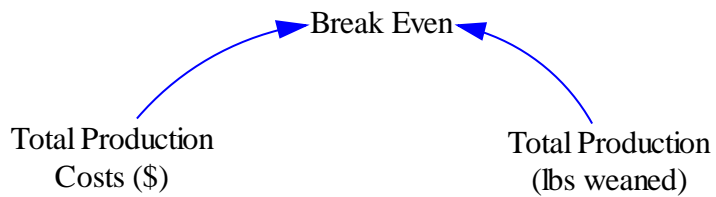


Figure 3.1: Break-Even Direct Drivers.

However, as was discussed in the previous section, these variables alone are not enough to adequately simulate BE since there are several variables which influence costs and productivity. Mapped in Figure 3.2 are the directions of causality for the next layer of variables. Although these variables do not directly affect BE, they must still be included in the model, as they indirectly influence this measure through their relationship with the direct factors that comprise the BE metric.

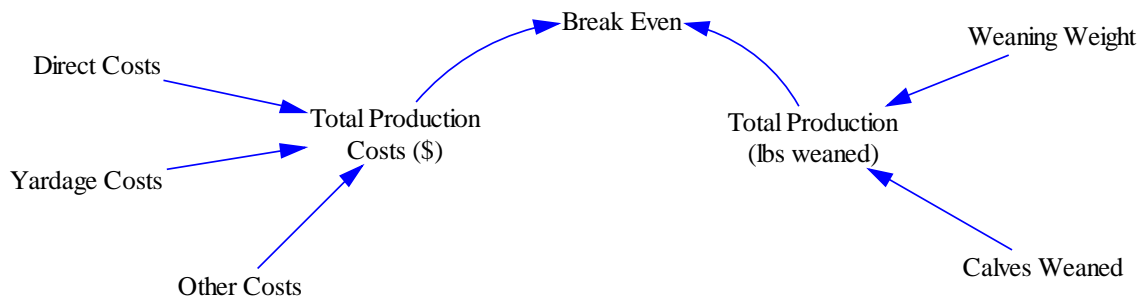


Figure 3.2: Break-Even Second Level Drivers

There is still another level of variables that need to be added to those model in Figure 3.2, as several of these cost and productivity variables are not exogenously determined. Most notably, the influence of factors related to the brood cows are not yet incorporated into the model. This short-coming must be addressed, as the brood cattle are the foundation of several of these costs as well as the total production level of the cow-calf enterprise.

Figure 3.3 shows the interactions that the variable for number of brood cows, or herd size, has with several other variables in the model. This variable influences the BE of the cow-calf enterprise by its indirect relationships with both costs and production. The importance of herd size on ranching profitability was motivated by the review of literature, which indicated that herd size can play an important role even though its influence on economic efficiency is still open for debate.

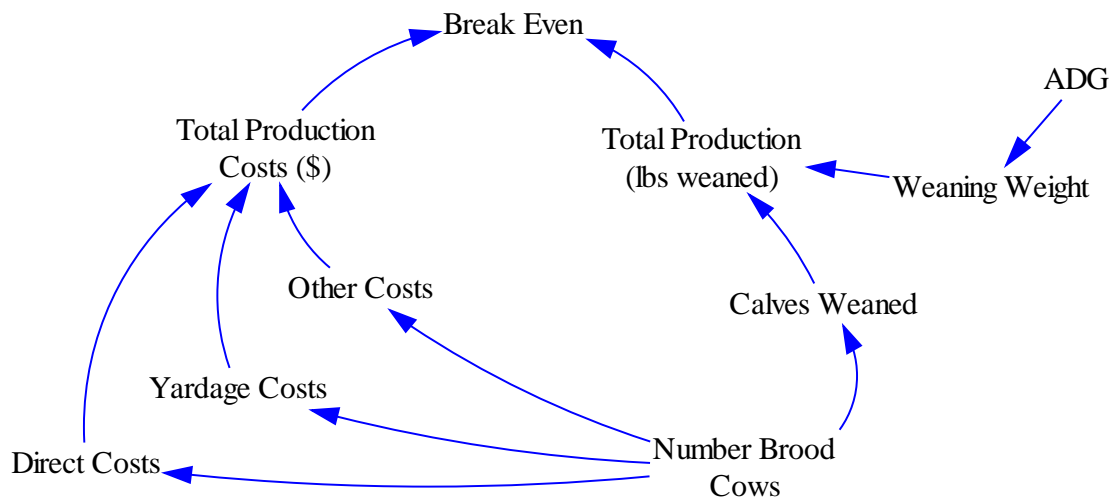


Figure 3.3: Break-Even Third Level Drivers

The conceptual model laid out in Figure 3.3 will be the framework on which the model for BE is based. However, this model is not yet able to simulate the effect that altering production practices to meet EU compliance requirements would have on BE. The next step in building a model that can simulate BE under EU compliance, as well as conventional production, is to further understand how these production requirements interact with typical production processes and the adjustments that the model requires to mimic the impact that will be had on a cow-calf operation.

3.5 Elements of Compliance

3.5.1 Production without GEPs

The EU prohibited substances of concern for the cow-calf segment of Canada's supply chain include zeranol, progesterone, estradiol benzoate, and estradiol-17 beta. These are the active ingredients in the four hormone implant products approved for suckling calves in Canada (AAF, 2008). Although these products have different active ingredients, growth response to them is quite similar amongst beef calves. The average response of steer calves to either zeranol or progesterone estradiol-benzoate combination implants is an addition of 0.10 lbs to their ADG. Growth responses from heifers tend to be slightly higher, with a 0.12 lb addition to ADG when treated with zeranol (Selk, 1997).

Production of beef calves without use of these growth enhancing products will result in foregone production, as weaning weights are expected to decline relative to their potential without the use of hormonal implants when all else is held constant. This loss to biological performance will impact the BE of the cow-calf enterprise by decreasing the pounds of calf

weaned. Generally improved biological performance reduces per-head production costs, especially when comparing producers operating under similar climatic conditions (Alberta Agriculture and Food, 2011; Ramsey et al., 2005; Samarejeewa et al., 2012). Therefore, the model in Figure 3.3 needs to be adjusted so the effect that removal of hormone implants from the production process has on production levels can be simulated and its effect on the BE measure captured.

The other capacity in which foregoing GEPs influences cost of production is through direct costs. Purchasing GEPs to administer represents an additional direct cost, which increases their total production costs. Thus, foregoing the use of these products also affects the total COP part of the BE calculation. This is another aspect of compliance with the program that needs to be added to the direct costs component of the model depicted in figure 3.3.

3.5.2 Record Keeping, Identification, and Administrative Tasks

As can be easily seen throughout the program description, abstaining from implanting calves with the prohibited substances is just one small component of the EU program. Also required is the assurance that the calves were not implanted, which this program partially achieves through inspections and traceability requirements at the producer level. Proof that cattle for EU export have never been treated with growth enhancing products relies heavily on identification and record keeping, responsibility for which falls upon the producer. Therefore, producers enrolling their calves in the EU program to access this marketing channel must take on additional administrative labour burdens beyond what is required for selling calves through conventional channels.

All Canadian cattle must carry an approved radio frequency identification (RFID) tag, shown in Figure 3.4, prior to leaving their farm of origin to comply with the Canadian Cattle Identification Agency (CCIA) traceability program. Doing so is now mandatory for Canadian beef producers, with financial penalties for non-compliance being as large as \$10,000. Each RFID tag is embedded with a unique identification number, which is recorded in the national database along with the information of the producer to which it was issued through the tag distribution network (Canadian Cattle Identification Agency, 2009). In Alberta, producers are further required to age verify their cattle in the Canada Livestock Tracking System before 10 months of age or leaving the farm, whichever comes first (AAF, 2015). As compliance with the CCIA program is already mandatory, the traceability requirements for EU compliance do not present an additional cost to cow-calf producers.



Figure 3.4: RFID Tag
Source: Author's photo

However, not all producers will have adequate identification practices in place for automatic compliance with the EU program (Manglai, 2016). If some calves on the farm are to be treated with hormone implants and sold via other channels, the calves enrolled in the EU program must be marked so they can be easily identified visually. Thus, they would require an alternative identification system beyond the compulsory RFID tag. The reason for an alternative

ID method is the fact that RFID tags are small and their numbers are difficult to read without an electronic reader, making them impractical for distinguishing individual animals from one another during a walk-through inspection (CFIA, 2016).

Another issue with meeting the traceability standards of the program arises with the tag replacement report component, which is not required by the CCIA. For EU-intended calves, any lost or revoked RFID tags need to be replaced and thoroughly documented prior to leaving the farm of origin. To complete the tag replacement report shown in Appendix A, information is needed on the number of the replaced RFID tag, how the missing tag and animal were identified, the number of the replacement tag, the date of the re-tagging, and the person who did it (CFIA, 2016). As approximately 4 percent of RFID tags go missing after being applied (CCIA, 2016), this report will likely need to be filled out each year if the calves are tagged in the spring, several months prior to leaving their farm of origin (Hays, 2010). In this case, an alternate ID system would also be needed to cross reference with the RFID tag numbers, even if all calves are to be enrolled and there is no reason to distinguish them from one another. Although not explicitly required by the program, having a second form of ID also tends to be the common practice for existing participants in the program (Faintuck, 2017; Fenton, 2017; Hagel, 2017; Kostelansky, 2017).

Shown in Figure 3.5 is how an RFID tag and an alternate ID tag, also called a ‘dangle’ tag, appear on an animal. As can be observed in this picture, the RFID tag does not lend itself well to the purpose of identifying individual animals upon visual inspection. Its small size makes the numbers very difficult to read, and they can frequently be covered by hair. Conversely, the figures written on the white dangle tag can easily be seen. Identification of individual animals at

the farm level, for purposes of herd management, favors the larger dangle types of tags that can be adapted to any numbering system (Lastiwka, 2014). For reasons already discussed, appending both an RFID and a dangle ID tag tends to be practiced by producers enrolled in the program (Faintuck, 2017; Fenton, 2017; Hagel, 2017; Kostelansky, 2017).



Figure 3.5: RFID and Dangle Tag
Source: Author's photo

The subsequent burden for producers once adequate identification procedures are in place is the maintenance of inventory records. EU certification requires that records of animals enrolled in the program must be kept for at least 3 years by the farm of origin from the date that the calves were born. Thus, another additional task is required by producers wishing to enroll, as they will need to fill out the Register for Birth Farms, included in Appendix B. This document requires a list of the approved tag numbers of the calves enrolled in the program, which need to be linked to a transfer certificate number and date. The transfer certificate, Appendix C, is another piece of documentation which the producer is responsible for completing prior to

transferring the calves to another farm, feedlot or auction market. This documentation is specific to EU program enrollment only, thus presenting a new additional administrative cost to producers (CFIA, 2016).

As a result of these additional tasks, which are not required for conventional marketing channels, an increase in labour expenses are expected to be associated with program compliance. This is another component of the model shown in Figure 3.3 that will need to be adjusted, so that the impact of the administrative burden of meeting EU export regulations on BE can be simulated. Although there is some overlap between standard requirements under Canada's mandatory traceability program and the EU export program, the latter demands more thorough record-keeping which poses an increase in labour hours to maintain them.

3.6 Compliance Scenarios

Removal of growth promoting technologies, added record-keeping burden and time requirements for the certification process influence BE. However, these impacts will not be homogenous across all producers, as there is a large degree of variation in production practices amongst cow-calf producers. Many producers already choose to not implant their calves (WBDC, 2015), and the degree of record keeping undertaken can vary from operation to operation (Manglai, 2016). Therefore, the cost of meeting certification requirements for EU export will depend on the types of practices already in place for a particular operation.

To achieve more detailed estimates of the cost difference between EU certified and conventional production, costs will be simulated for various compliance scenarios. In an effort to reflect a realistic cost for complying with the EU program requirements, more than one scenario

must be taken under consideration as cow-calf production practices can vary widely between firms. Some practices, which producers may or may not follow regardless of their intent to sell EU certified calves, will inadvertently bring them closer to or further from meeting the compliance requirements. As a result, some producers will face a smaller incremental change to their production practices than others when adjusting their management to comply with the program. Therefore, more than one compliance scenario will be simulated to reflect how varying degrees of change affects BE. In each scenario, the BE prior to compliance will be compared to the BE following the necessary adjustments being made. The difference in BE before and after compliance represents the price premium needed by the producer to cover additional expenses and make them no worse off by following EU compliant protocols.

Certain components of production costs will apply consistently to all scenarios, regardless of the production adjustments being made. First of all, the costs directly related to the maintenance of the brood cows will be equivalent across scenarios. EU compliance is concerned solely with the practices administered to the calves which are intended to enter the production chain that leads to their export. None of the program requirements restrict production processes associated with the brood cows or their traceability status, as these cattle are not intended for EU meat export. Therefore, the costs directly related to the brood cows are not expected to change in response to the EU compliance status of the operation, and will remain as the status quo. Rather, only the costs that are related specifically to the processing and traceability for the purpose of program compliance of the calves will be considered. In the following discussion of the compliance scenarios, it is the adjustments to these production processes specifically that will be considered.

Additionally, certain elements of compliance will apply consistently across firms, regardless of the production practices already in place. These concern the administrative labour involved in maintaining the documentation that is specifically for maintaining status in the program and the CFIA inspection which enrolled producers are subject to at least once per year. Due to these tasks being specific to enrollment in the program alone, it is assumed that prior to seeking certification no producers were completing them. Therefore, all compliance scenarios will have the administrative labour costs associated with maintaining the program applicable to them.

3.6.1 Scenario A

The first compliance scenario models a case of being ‘least complaint’, which can be thought of as operations that must undergo the largest adjustments to their existing procedures to meet EU specifications. It is assumed in this case that these producers are utilizing the prohibited growth enhancing products and meeting the minimal requirements for traceability and identification protocols. For this group to transition to EU complaint production they will experience a decline in productivity by foregoing the implant, assuming they keep all other management practices that influence that growth rate of calves constant. However, foregoing of the implant will eliminate the cost of purchasing it, so there will also be a decrease in veterinary expenses.

The second adjustment to their existing protocols is the implementation of an alternative ID system. It is assumed for scenario A that these producers are RFID tagging their calves during routine spring processing, as this is a convenient time to do so. Therefore, this group will need to expend additional labour hours to complete the task of applying an alternative individual ID to

their calves so that it can be cross-referenced with the RFID tag. It is assumed that the individual ID tagging will occur in spring as well, shortly after the calf's birth in line with common practice for producers that do tag (Larson, 2017; Hays, 2010). Thus, this task presents an additional demand for labour hours as it was not a practice being followed prior to enrollment.

3.6.2 Scenario B

The group of producers represented in this case are considered 'partially compliant', in the sense that they already partially meet the requirements for becoming EU certified by already having an alternative ID system in place in addition to standard traceability obligations. Therefore, in making the necessary adjustments they are only foregoing the use of hormone implants which affects productivity and veterinary expenses. Implementing an alternative tagging ID system does not present an additional cost associated with EU compliance for this scenario, as this labour cost was already being incurred regardless of their status in the program.

3.6.3 Scenario C

This scenario also represents a group of partially compliant producers, but the components of their existing operation that already conform to EU requirements are exactly opposite of that in Scenario B. In this case, the producers already have chosen to forego the use of hormone implants, which means that adhering to the program requirements will not affect their existing productivity level. However, these producers are assumed to RFID tag their calves in the spring and do not have an alternative ID system in place, which is an incremental labour expense they would have to incur if they were to join the program.

3.6.4 Scenario D

These producers represent those that already have in place most of the required practices to meet the program requirements. It is assumed this group has already foregone the hormone implant and has in place an alternative ID system. Therefore, their productivity and ID protocol expenses are expected to remain consistent following the transition to EU compliance. In this case, the administrative costs related to maintaining the program-specific documents and the time required for the annual inspection are the only additional costs that compliance will present, which applies to all of the other scenarios as well.

Table 3.1 summarizes the scenarios and the adjustments that would need to be made if the producer were to enroll in the EU program. Each ‘X’ in this table indicates a practice already being followed and represents an area of their typical production processes that would need adjusting, resulting in a change to their existing production costs. As can be seen, the CFIA program-specific documentation maintenance and the inspection present costs to all producers regardless of their existing practices or status in the program.

Table 3.1: Summary of Compliance Scenarios

	A	B	C	D
Implant Calves	X	X	-	-
RFID Tag Only	X	-	X	-
CFIA Inspection & Paperwork	X	X	X	X

3.7 Conceptual Systems Model

Illustrated in Figure 3.6 are the drivers of production cost that will be considered in this analysis and how the previously discussed compliance requirements are related to them. Each part of this system influences the BE required for a cow-calf operation. Therefore this model can mimic each compliance scenario, both before and after production processes are adjusted to enroll in the EU program, to reflect the impact that compliance has on BE. Thus, it enables comparisons to be made not only between production before and after enrollment, but between hypothetical groups of producers represented by each scenario. This provides a framework by which the minimum premium that would be needed to procure a supply of EU complaint calves can be estimated, as the benefits of participation in this marketing channel must outweigh the costs incurred to comply (Brocklebank, 2004).

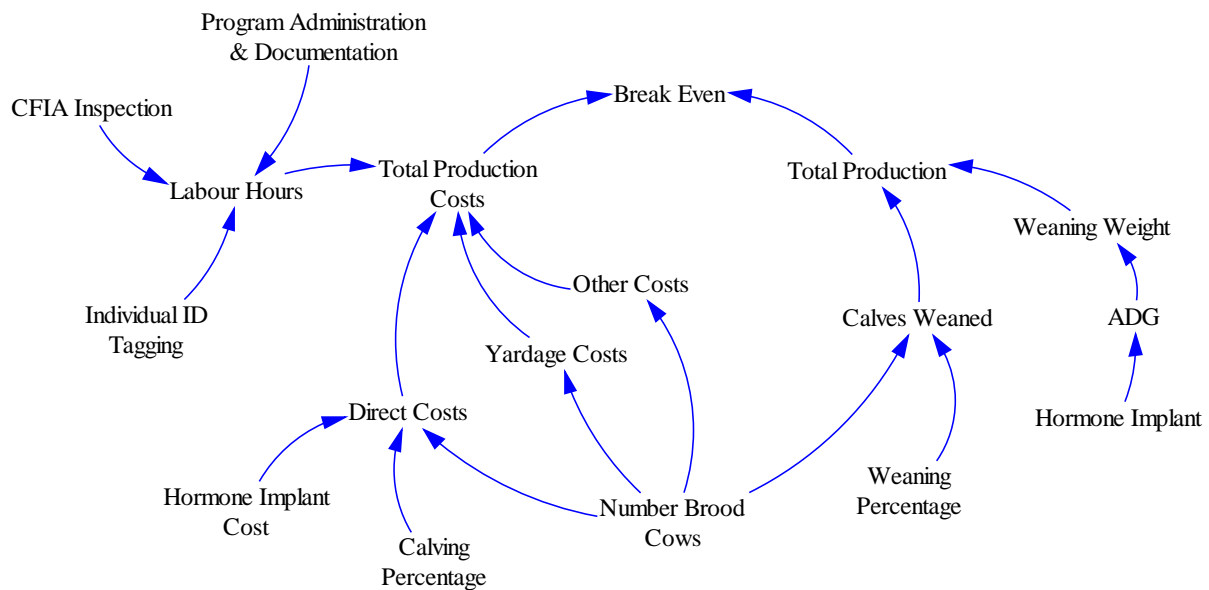


Figure 3.6: Conceptual Model

Chapter 4 – EMPIRICAL FRAMEWORK

4.1 Introduction

This chapter will describe the process of parameterizing the conceptual model developed in Chapter 3 and expressing it in mathematical terms. The parameters and equations which govern the relationships between variables are extrapolated from data found in a variety of sources. The goal is to create a systems model that mimics the costs and productivity of typical western Canadian cow-calf operations as they transition from their status quo production practices to EU certified ones. The scenarios described in Chapter 3 can then be simulated to estimate the BE requirement for each scenario before and after compliance, enabling the determination of the premium each group of producers needs to gain their participation in the EU beef market channel.

The Vensim program, developed by Ventana Systems Inc., is the modelling software used to build and simulate the model. Specifically the Personal Learning Edition (PLE) and PLE Plus were used interchangeably. Besides having the capacity of build and simulate systems models, this software had a ‘Synthesim’ function, which facilitated sensitivity analysis by enabling the user to simultaneously alter parameter values and see instantaneous changes to the results. Described throughout the remainder of this chapter are the assumptions underlying the parameter values and equations used to develop a usable model, and a tabulation of all of the elements input into the Vensim software.

As is illustrated in Figure 4.1, approximately 75 percent of all Canadian beef calves are produced in the western Prairie Provinces of Alberta, Saskatchewan and Manitoba (Statistics

Canada, 2014). Therefore, information from these regions will be used to parameterize the BE model. The provincial proportions of beef cow inventory from each province are 49, 36 and 15 percent for Alberta, Saskatchewan and Manitoba, respectively (Statistics Canada, 2014).

Although there exists cost of production (COP) budgets for the cow-calf enterprise in each of these provinces, only the budgets from Alberta and Saskatchewan will be used to parameterize the BE model. The methodology of Manitoba's production budget is the reason for its exclusion.

Alberta and Saskatchewan's COP data is taken from producer surveys, whereas Manitoba Agriculture Food and Rural Initiatives (MAFRI)'s data is compiled based on a set of assumptions made about a hypothetical cow-calf operation, rather than based on actual production. Therefore, the results of MAFRI's production budget are very different from those of the other Prairie Provinces. Secondly, the expense categories used are quite different than those for Saskatchewan and Alberta's COP, which makes the adaptation of MAFRI's COP to fit the model's defined expense categories difficult. In particular, the MAFRI COP has additional expense lines that do not align with the other provinces' in some cases, and in others, there are expense lines missing that the others included. Finally, Manitoba's share of the beef cow inventory is small, so the influence that COP in this province, if included, would have been small in the overall weighted average.

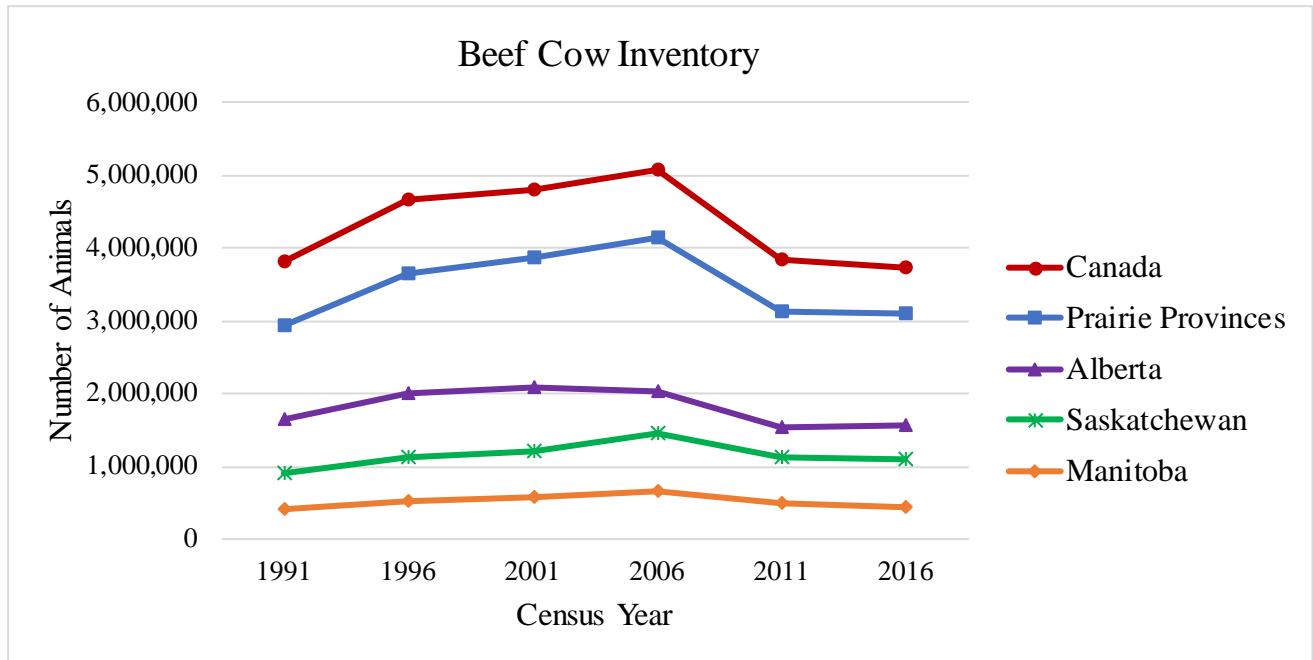


Figure 4.1: Beef Cow Inventory Canada and the Prairie Provinces
Source: Statistics Canada (2017) Table 004-0221

The COP data used to parameterize the cost components of the BE model includes the WBDC's 2012 Saskatchewan Cow-Calf Cost of Production Analysis (Larson, 2013) and Alberta Agriculture and Forestry's AgriProfit\$ Multi-Year Economic, Productive & Financial Performance of Alberta Cow/Calf Operations (AAF, 2016). Both of these reports use survey data from producers across the provinces who voluntarily offered to provide information regarding their cow-calf operations. The WBDC survey was conducted for the 2012 production season, whereas AAF has surveys spanning several years. For the development of this BE model, data from the common year, 2012, will be used. Also to be taken from these surveys is the required productivity data, as variables such as herd size and weaning weight are related to COP. Due to the relationship between productivity and profitability, the productivity parameters in the model must correspond with the COP data.

The data contained in these COP budgets for Alberta and Saskatchewan will need to be combined in some way to reflect typical cost and productivity values for producers in these provinces. To do so, a weighted average approach will be taken using information from the 2011 Census of Agriculture, which is the closest census to 2012. These results indicate that between the Saskatchewan and Alberta beef herds, Saskatchewan is home to 42 percent of beef cows and Alberta is home to the other 58 percent (Statistics Canada, 2014). These proportions will be used to weight the data from each province when an average is being calculated. Summarized in Table 4.1 is the COP survey results for Saskatchewan and Alberta individually, as well as the weighted average COP. The data summarized in Table 4.1 represents a sample size in excess of 50 producers located throughout these two provinces (Larson, 2013; Oginskyy, 2017).

Table 4.1: Provincial COP Survey Results

# of Cows	Saskatchewan 354	Alberta 198	Weighted Average 264
	Costs (\$/Cow)		
Winter Feed ¹	\$189.14	\$277.44	\$240.35
Grazing ²	\$125.74	\$218.16	\$179.34
Veterinary & Medicine	\$25.46	\$18.49	\$21.42
Breeding Stock	\$52.47	\$0.73 ³	\$22.46
Total Direct Costs (A)	\$392.80	\$514.82	\$463.57
Fuel	\$25.62	\$13.95	\$18.85
Machinery Repairs	\$17.71	\$11.47	\$14.09
Building & Corral Repairs	\$9.58	\$4.41	\$6.58
Utilities & Misc.	\$21.04	\$15.33	\$17.73
Custom Work	\$8.75	\$5.75	\$7.01
Paid Labour	\$11.23	\$13.26	\$12.41
Unpaid Labour	\$71.70	\$31.47	\$48.37
Taxes/Lic./H2O	\$8.86	\$7.95	\$8.33
Depreciation	\$37.19	\$34.94	\$35.89
Lease Payments	\$1.21	\$1.00	\$1.09
Total Yardage Costs (B)	\$212.90	\$139.53	\$170.34
Capital Interest	\$6.00	\$3.70	\$4.67
Operating Interest	\$7.46	\$1.01	\$3.72
Trucking/Marketing Costs	\$11.32	\$12.15	\$11.80
Share/Lease Cattle Payment		\$1.99	\$1.15
Total Other Costs (C)	\$24.78	\$18.85	\$21.34
Total Costs (A+B+C)	\$630.47	\$673.20	\$655.26

1-Winter feed includes bedding

2-Grazing includes salt and mineral

3-Bull Rental/Breeding Fee

As can be observed in Table 4.1, there are some large disparities between average expenses reported for these provinces. This may be related to several issues, such as a small sample sizes, differences in the interpretations of the expense categories by survey respondents, or the wide degree of variability between cow-calf producers and their respective COPs. As a result, the COP data used to build the model may be inconsistent and taking a weighted average may cause the resulting parameter to be an inaccurate representation of the true population

parameter. However, alternative sources for Saskatchewan and Alberta cow-calf COP are not available, so this data is to be utilized and interpreted cautiously.

4.2 Exogenous Variables

The variables described throughout this section represent the system boundaries. These variables are considered exogenous in the sense that they are determined outside of the system, and so they are parameterized using values that are taken as a given. In reality, there can be many factors which influence the value of these variables. However, this model is primarily interested in simulating the BE for cow-calf production, so several simplifications were made to keep the model focused simulating this metric without unnecessary steps. Systems modelling inherently requires the abstraction of reality, and so simplifying assumptions were made to ensure the model under development maintained its focus on the stated research objectives (Ruth and Hannon, 1997).

4.2.1 Herd Size

Herd size refers to the number of brood cows and heifers on inventory at the start of the year (AAF, 2016). The average herd size across all surveyed producers are reported directly in the COP budget publications. For the Saskatchewan survey, the average herd size was 354, and for the Alberta survey it was 198. To parameterize this variable in the model, the weighted average was taken between the two provincial surveys based on the proportion of beef cows residing in each province. The parameter value used is 264 brood cattle.

4.2.2 Weaning Percentage

Along with herd size, the average number of calves weaned at the end of the season was also reported in the COP budgets. Therefore it was possible to calculate an average weaning percentage between the two provinces. The measure was derived by dividing the number of calves weaned by the number of brood cattle, as defined in section 4.2.1. This yielded an average weaning percentage of 86.9 percent for Alberta and 87.6 percent for Saskatchewan. The weighted average between the two provinces is 87.2 percent, which is the value that will be used to parameterize this variable.

4.2.3 Calving Percentage

Calving percentage refers to the number of live births per of brood cow. This metric is necessary to include in the model, as expense calculations for items such as the hormone implants or tagging labour hours are determined by the number of live calves in the herd at spring time, and incurred for calves that do not survive to weaning time. Data for number of live births was not included in the Saskatchewan COP survey, but was for Alberta. The calving percentage calculated from the Alberta survey was 90.9 percent, which will be the parameter value used, as a calving percentage from Saskatchewan was not available.

4.2.4 GEP Response

Implants can add an additional 0.1 pounds to the average daily gain rate over the period from implanting to weaning, approximately 150-210 days, with this effect being observed consistently across different active ingredients (Selk, 1997). Therefore, the average effect of implanting ranges from 15 to 21 pounds of additional weaning weight compared to a non-

implanted calf. The midpoint of this range, 18 pounds, is the parameter used to value the gain response for implanting calves. The GEP response variable will interact with the implant binary decision variable and the base weaning weight to reflect the change in production when GEPs are administered to the calves.

4.2.5 Base Weight

Base weight refers to the expected average weaning weight when growth enhancing products are not administered to the calves. It is important to use a value for base weight that is associated with the COP data being used to parameterize the model. The reason for this is the relationship between biological performance indicators, which includes weaning weight, and profitability (AARD, 2011; Miller et al., 2001; Taylor and Field, 1995). For this variable, the weaning weight data recorded in the COP publications is utilized. They reported an average weaning weight of 513 lbs per calf for Saskatchewan (Larson, 2013) and 575 lbs per calf for Alberta (Oginsky, 2017). Using the same weighted average applied to the COP data of 42 percent for Saskatchewan and 58 percent for Alberta, the average weaning weight is calculated to be approximately 550 lbs per calf. This 550 lb average weight cannot yet be used to parametrize the model, as this average includes calves that were implanted and those that were not. The assumptions of a 24 percent portion of treated calves (WBDC, 2015) and an average 18 lbs difference in weight (Selk, 1997) were used to calculate an average weaning weight of 546 lbs for untreated calves⁷.

⁷ The following formula was used to solve for an overall average weaning weight of 550 lbs using Excel Solver software; $24\% * (x+18) + 76\% * x = 550$.

4.2.6 Binary Decision Variables

The binary decision variables indicate a choice to be made by the producer. These variables will take on a value of 0 if the protocol of concern is not being implemented, and 1 if it is. They will interact with the equation set up for the endogenous variables to turn additive parts of that equation ‘on’ or ‘off’, depending on whether the decision variable takes on a value of 0 or 1. This will allow several simulations to be run using the same model, but with different combinations of management decisions being made, thus enabling the simulations of BE for the scenarios described in Chapter 3.

Hormone Implant – this variable will be set to a value of 1 if the producer implants their calves, and 0 if not. The assumption made here is that producers enrolling in the program will forego the use of implants for all of their calves, even though it is possible to segregate implanted from non-implanted cattle and remain compliant under the program framework. However, choosing to enroll a mixed-status herd in this program makes the documentation and CFIA inspection procedures considerably more rigorous. Thus, cow-calf producers currently enrolled in this program tend to forego GEP usage on all of their cattle (Faintuck, 2017; Fenton, 2017; Hagel, 2017; Kostelansky, 2017). Additionally, given the low rate of implant usage across all producers in this segment of the supply chain, foregoing the use of implants seems to be a popular choice regardless of program status (WBDC, 2015).

This binary variable could interact with three endogenous variables; direct costs, labour costs and total production, which has already been discussed. Labour costs for actually administering the implant are assumed to be nil in this model. Most producers vaccinate, castrate and implant their calves around 2 months of age (Selk, 1997). This is also when the implant

procedure is typically done, in combination with other routine processes when calves are handled. This means that all of the labour associated with the preparation, gathering, sorting and restraining calves required for routine spring processing of animals will be not counted as labour costs for implanting, as these activities happen regardless of the implant procedure. Only the time associated with actually administering the implant can be considered an additional labour burden associated with implanting. As this is a very quick procedure, taking only a few seconds per calf, the incremental labour cost for implanting is considered to be nil and not included in the simulations.

Purchasing GEPs affects the veterinary expense category, which is a component of direct costs. There are four hormone implant products currently registered for use in beef calves in Canada. Price data was gathered from retailers which handle suckling calf implants, located in Saskatchewan and Alberta. The most commonly offered implant product was Ralgro. No price information was found for Component E-C, but information for its 'look-alike', Synovex-C, was obtained. These products are summarized in Table 4.2, with the average price across them being \$1.72 per dose. This price will be multiplied by the binary decision variable for implanting, as well as the calving percentage since only live calves at spring processing will be implanted, and be added to direct costs. Therefore, when producers choose to implant, the cost of the product will be reflected in the cost of production calculation.

Table 4.2: Approved Products for Suckling Calves in Canada

Product	Active Ingredient	Approved Use	Price
Ralgro	36mg zeranol	Nursing steer calves and heifers intended for breeding > 30 days old to weaning	\$1.45/dose
Synovex-C	100mg progesterone & 10mg estradiol benzoate	Nursing steer calves and heifers intended for breeding > 45 days old to < 410lbs	\$1.30/dose
Compudose	24mg estradiol-17 beta	Steers > 175 lbs, not for use in heifers intended for breeding	\$2.40/dose
Component E-C	100mg progesterone & 10mg estradiol benzoate	Nursing steer calves and heifers intended for breeding > 45 days old to < 410lbs	N/A
Source: Alberta Cow-Calf Guide; various veterinarian clinics and farm supply retailers			

Individual ID Tagging – When this variable equals zero, it indicates that the manager chooses to not use an alternate individual ID system. Individual ID tagging affects two endogenous variables: labour and direct costs. This task is assumed to take approximately 5 minutes per calf, and requires two people⁸. This amounts to 10 minutes of total labour required per calf to individually ID tag. There is also an expense associated with purchasing the tags. Floppy ID tag

⁸ This estimate is a result of conversations with various producers and the WBDC.

prices range from \$1.28 to \$1.68, depending on brand and size⁹. Therefore, an average price of \$1.48 per tag is assumed.

CFIA Inspection, Program Administration and Documentation – An important assurance of compliance with the program for certifying GEP free beef is annual on-site assessments conducted by a CFIA approved veterinarian. The purpose of these visits is two-fold: to confirm that the producer is maintaining their commitment to not using GEPs in EU-destined calves, and to procure the necessary documentation so they can submit their recommendation to a CFIA district veterinarian. Typically, these visits occur once per year for producers that are familiar with the program and require 1.5 hours to complete (CFIA, 2016; Faintuck, 2017; Fenton, 2017; Kostelansky, 2017).

The on-site assessments would not be completed free of charge, as the veterinarian must be compensated for their time in completing them. Therefore, this binary decision variable will be associated with a veterinarian service and mileage fee. Using a general professional rate from the Saskatchewan Veterinary Medicine Association's rate guide, which is \$249.00 per hour, the time for the inspection is estimated to be valued at \$373.50. In addition to that, the veterinarian would need to charge mileage for travelling out to the farm to conduct inspections. To value this expense the base mileage rate of \$59.90, which applies for travel to all sites within 18 km, is used. Thus, the total annual charge for the veterinarian inspection is estimated to be \$433.40. It should be noted that this estimate may be under-valued as a result of using only the base mileage rate. In reality, producers may be located more than 18 km from a CFIA approved veterinarian, so the mileage charge for the on-farm visit could be larger. However, the wide geographic range

⁹ Price information was gathered from livestock supply retailers including: United Farmers of Alberta, Peavey Mart, and Canadian Co-operative Wool Growers.

over which cow-calf production takes place makes the assumption of an average distance between a producer and an approved veterinarian unreliable. Secondly, these inspections are not highly time sensitive so it is likely that the veterinarian could schedule appointments in advance that are close together and reduce travel time. For these reasons, the base mileage rate will stand as the proxy for mileage charge in this analysis, but it needs to be acknowledged that this may undervalue the actual charge for a specific producer.

In addition to on-site assessments, producers are also responsible for the maintenance of accurate inventory records and adequate documentation in addition to what is typically required (CFIA, 2016). However, with the use of computers, meeting this requirement is not a highly time consuming task. Conversation with a currently enrolled producer suggested that approximately an hour per year is all the time needed, in addition to inspection, for completing the CFIA administrative component of the program (Hagel, 2017). Therefore, a total of 2.5 hours per year is assumed to be the labour time requirement for enrollment.

4.3 Endogenous Variables

4.3.1 Weaning Weight

Equation 3 governs the relationship between base weaning weight and the administration of an implant. It calculates the average weaning weight of each calf with or without the use of a hormonal implant, depending on the value that the binary decision variable takes.

$$\textit{Weaning Weight} = \textit{Base Weight} + (\textit{GEP Response} * \textit{Hormone Implant}) \quad (3)$$

4.3.2 Calves Weaned

This variable is a function of the number of brood cows in the herd and the weaning percentage. This value must be consistent with the average number of cattle that correspond with COP data used, as economies of size can influence this measure (Featherstone, Langemeier, Ismet, 1997; Jones, 2000; Leung, Kulshreshtha and Brown, 1991). An average weaning percentage of 87.2 percent is applied to the number of breeding cows in the herd to determine the number of calves weaned at the end of the production season. This percentage reflects both pre- and post-natal calf losses throughout the year. The number of calves weaned is governed by Equation 4.

$$\text{Calves Weaned} = \text{Number Brood Cows} * \text{Weaning Percentage} \quad (4)$$

4.3.3 Total Production

Total production makes up the denominator of the BE equation, representing the total pounds of weaned calf produced for that operation. It is calculated by multiplying the number of calves weaned by their average weaning weight, as shown in Equation 5.

$$\text{Total Production} = \text{Calves Weaned} * \text{Weaning Weight} \quad (5)$$

4.3.4 Labour Costs

Besides weaning weights and veterinary expenses, the other component of BE that is affected by following EU compliance procedures is labour. The COP budgets used for this analysis separate paid and unpaid labour. The primary difference between these expense lines is the fact that paid labour is a cash cost and unpaid labour is considered a non-cash expense, or

living withdrawal, for the time spent by the operator or ranch owner and their family in managing their herd (Larson, 2013). For the Saskatchewan COP surveys, producers are asked to assign a value to their labour, even though this ‘wage’ may not actually be paid out. Because there is no guideline by which producers could value their unpaid labour, large degrees of variability exist between the valuations that survey respondents give for their time (Larson, unpublished data).

However, the labour expense category is influenced by enrollment in the EU program, and so it needs to be parameterized in a way that enables comparison between management decisions. The Alberta survey used a value of \$10 per hour for unpaid labour and \$15.40 per hour for paid labour (Oginsky, 2017). Using these values, the average number of labour hours per cow was 4.0 in 2012, and averaged 4.3 per cow from 2011-2015. This value is considerably lower than other estimates for western Canada. Older estimates for labour hours per cow are reported by Millang (2002), which indicate that annual labour hours per cow can range from 6.67 for low-cost producers to 14.63 for high cost producers. The assumption made by MAFRI (2010) for their COP budget suggests that 9 labour hours per cow are required for the cow-calf enterprise. These estimates for labour hours per cow are combined by taking the simple average of 4.3, 9, and 10.65, which is the median for Millang’s estimate range. The resulting value for average labour hours per cow is 8. For the assumed herd size of 264 cows, the labour hours spent each week is calculated to approximately 40, similar to a typical work week for other professions. This average of 8 labour hours per cow will be used to parameterize the model.

The average hourly wage rate for workers in agricultural production was \$24 in 2012 for Alberta and Saskatchewan (Statistics Canada, 2017). This will be the wage rate used to value the

annual labour hours input to production. Although paid and unpaid labour was valued differently in the COP surveys, a consistent value for labour will be used here. First of all, the aforementioned wage rate is assumed to be the wage required to procure labour with the skills needed on a cow-calf operation. Secondly, it is also considered to be the opportunity cost for the ranch owners and their families that spend time managing it. The skills utilized in managing their own herds would be employable at the \$24 rate at other operations, thus representing the manager's opportunity cost for choosing to forego employment on another ranch to manage their own.

The 8 labour hours per cow estimate is assumed to be derived from a range of producers that have adopted identification and record-keeping practices to differing degrees (Manglai, 2016). As these practices take time, and labour is another variable which must reflect changes in production practices to meet EU regulations, the labour hours used to calculate this cost must reflect the time required to ID calves individually and maintain records. The common practice for individual calf identification is to place a large tag in their ear, which is marked with a combination of letters or numbers in accordance with the ID system in place for that operation and can be read from a distance (Lastiwka, 2014). Survey results for western Canadian cow-calf producers indicate that 93 percent of producers individually ID their calves (Manglai, 2016). It is assumed that this tagging occurs shortly after birth when the calf is easiest to handle and requires 2 people an average of 5 minutes per live calf for applying the tag and recording it, totalling 10 minutes per calf¹⁰. This includes time for preparation of the tag and equipment needed, separating the cow, restraining the calf and applying the tag. The portion of producers that do not individually ID their calves do not incur these additional labour hours and are expected to

¹⁰ Estimate gathered from conversations with cow-calf producers and WBDC staff.

experience a smaller labour cost as a result. Therefore, the average number of labour hours per cow for producers that do not maintain individual calf ID's is calculated to be 7.86¹¹, assuming a proportion of 93 percent who follow this practice and 7 percent that do not (Manglai, 2016).

This value will serve as the base number of hours per cow that are required for standard management. The binary decision variables and the labour hours associated with each task they represent, as described in greater detail in section 4.2.4, will influence this base value for labour as governed by Equation 6.

$$\begin{aligned} \text{Labour Costs} = & (7.86 + \text{Individual ID Tag} * 0.17 * \text{Calving Rate}) * \\ & \text{Number Brood Cows} * 24 + \text{CFIA Inspection \& Admin.} * 2.5 * 24 \end{aligned} \quad (6)$$

4.3.5 Direct Costs

Direct costs refer to those costs related to the maintenance and health of the cattle. Enrollment in the EU program will influence this expense category in three ways, as there are costs for purchasing ID tags, the hormone implant and a charge for the veterinarian's time in conducting the on-farm inspection. The veterinary and medicine expense line has a weighted average value of \$21.42 per cow, which is assumed to be gathered from a distribution of producers who implant and those that do not. Assuming an adoption rate of 24 percent for implants (WBDC, 2015), a per dose cost of \$1.72, and a calving rate of 90.9 percent, as only the live calves at spring processing will be implanted, the veterinary expense line is estimated to be

¹¹ The following formula was used to solve for an average of 8 labour hours per cow: $X * 7\% + (X + (0.17 * 90.9\%)) * 93\% = 8$, where X is the average number of labour hours for producers that do not individually ID their calves. The time required for tagging is scaled by the calving percentage to reflect the fact that only live born calves will receive a tag.

\$21.04 per cow for non-implanting operations¹². This \$21.04 value will replace the veterinary expense line value shown in Table 4.1 for the production scenarios when the producer does not implant. Also included in this calculation is the cost of purchasing individual ID tags, which is scaled by the calving rate as well. The base value for direct costs will also need to be adjusted to represent expenditures in this category when individual ID tags are not being used. Using the assumed per tag price of \$1.48 and an adoption rate of 93 percent (Manglai, 2016), the base direct cost value is estimated to be \$461.94 per cow¹³. Finally, the total annual cost of having a CFIA approved veterinarian inspection conducted is simply added to the total direct costs. Direct costs are therefore governed by Equation 7.

$$\begin{aligned} \text{Direct Costs} = & [461.94 + (1.72 * \text{Hormone Implant} * \text{Calving Percentage}) + \\ & (1.48 * \text{Individual ID Tag} * \text{Calving Percentage})] * \text{Number Brood Cows} + \\ & (\text{CFIA Inspection \& Admin.} * 433.40) \end{aligned} \quad (7)$$

4.3.6 Yardage Costs

Much like the direct cost category, most yardage costs will not change as the operation transitions to EU production protocols except for labour expenses. As was discussed in section 4.3.4, the labour expense line is removed from this category and treated as a separate variable in this model. Therefore, the paid and unpaid labour expenses reported in Table 4.1 have to be

¹² The following formula was used to solve for an average of \$21.42 per cow: $X * 76\% + (X + (1.72 * 90.9\%)) * 24\% = \21.42 , where X is the average veterinary expense for producers that do not individually implant their calves. The implant price is scaled by the calving percentage to reflect the fact that there is not exactly 1 calf implanted per brood cow as a result of losses. The new direct cost per cow is \$463.19, with a base veterinary expense of \$21.04.

¹³ The following formula was used to solve for an average of \$463.19, per cow: $X * 7\% + (X + 1.48 * 90.9\%) * 93\% = \463.19 , where X is the average veterinary expense for producers that do not individually implant their calves. The tag price is also scaled by the calving percentage in this case, motivated by the same rationale.

subtracted from the total yardage costs, yielding a per-cow yardage cost of \$109.56. The total yardage cost variable is therefore governed by Equation 8.

$$\text{Yardage Costs} = 109.56 * \text{Number Brood Cows} \quad (8)$$

4.3.7 Other Costs

The value for this variable is taken directly from the weighted average reported in Table 4.1, as these expenses are not anticipated to change in response to EU compliance status. The only expense line which may change could be ‘trucking and marketing’, as it may be the case that calves sold into the EU marketing channel will be done via novel marketing arrangements. However, cow-calf producers already market their calves in a variety of ways, including direct private treaties (WBDC, 2015). Therefore, this expense category is being left to proxy the expenses associated with any marketing regime that may be employed by the EU supply chain. ‘Other costs’ will be governed by Equation 9.

$$\text{Other Costs} = 21.34 * \text{Number Brood Cows} \quad (9)$$

4.3.8 Total Production Costs

The total cost of production is the summation of all expense categories, which are already expressed as a total value for the operation as a whole. Therefore, the total cost of production variable is determined by Equation 10.

$$\text{Total PC} = \text{Direct Costs} + \text{Labour Costs} + \text{Yardage Costs} + \text{Other Costs} \quad (10)$$

4.3.9 Break-Even

The variable of interest for comparing between production regimes is BE. Recall that BE refers to the price required for the firm to earn a normal profit. All of the variables discussed influence the BE price, either directly or indirectly through the total cost and production equations. BE is calculated by Equation 11.

$$\text{Break Even Price} = \text{Total Production Costs} / \text{Total Production} \quad (11)$$

4.4 Chapter Summary

The purpose of this chapter was to describe how the conceptual model built in chapter 3 was developed so that it could be used for simulations. This process requires each component of the model to be parameterized using assumed values for exogenous variables or an equation that dictates the outcome of endogenous variables. The parameter values and relationships were taken from various sources, including literature as well as personal communication. Serving as the base of the model parameters were the COP surveys for Alberta and Saskatchewan cow-calf producers, which provided initial cost of production values which could be manipulated to reflect alternate production scenarios. Adoption rate data also played a large role in distinguishing between production costs when certain protocols are foregone, as the survey data did not make these delineations. Therefore, it had to be assumed that the COP survey data was drawn from the same distribution as the adoption rate survey data.

The final model, shown in Figure 4.1, varies slightly from the conceptual model outlined in Chapter 3. Most of the variations were made so that the parameterized model has all of the exogenous variables required for calculations linked to the proper endogenous variables. The

other notable change is the elimination of ADG from the model. As was discussed in section 4.3.1, biological performance can be an important driver of COP, so it is necessary to parameterize the weaning weight variable using the weights reported in the COP survey. As there was not adequate information reported to determine the average ADG for the surveyed operations, a base weight which is adjusted for the usage of implants was used instead of ADG.

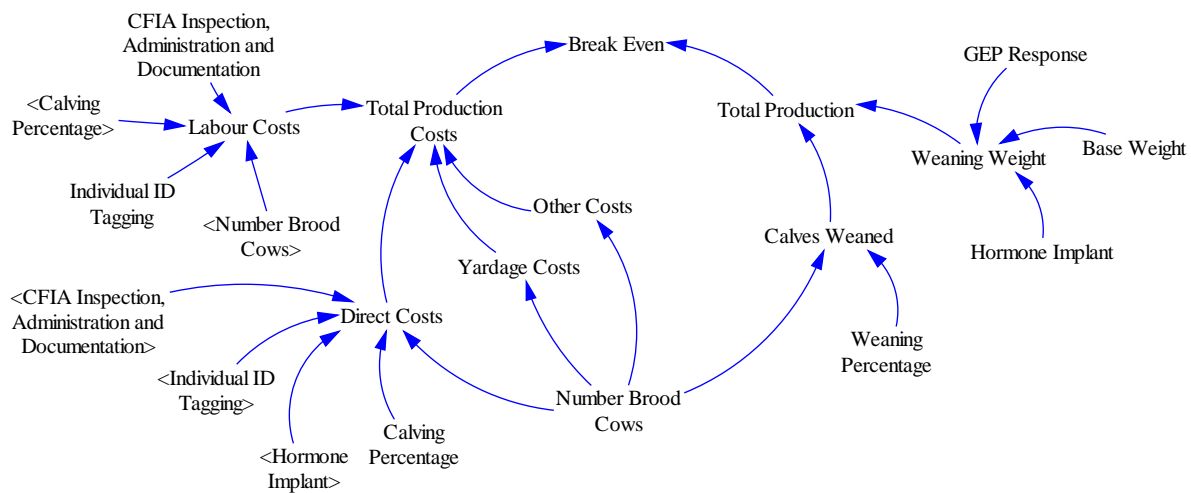


Figure 4.2: Structure of Empirical Model¹⁴

In this chapter, data from various sources was organized and applied to the systems model in a manner that is intended to mimic BE determination in reality. The parameters as they will appear in the actual computer model and the information sources for their creation are summarized in Table 4.3 and Table 4.4.

¹⁴ This figure depicts the model as it appears in Vensim. The angle brackets that surround some of the variables indicates the use of a 'Shadow Variable', which means that this variable is an exact copy of another variable in the system, and that its definition can be found by opening up the details for the originally created variable.

Table 4.3: Exogenous Variable Summary

Exogenous Variable	Value	Units
# Brood Cows	264	Animals
Base Weight	546	Pounds
GEP Response	18	Pounds
Weaning Rate	87.2	%
Calving Rate	90.9	%
Hormone Implant	0,1	Binary Variable
Individual ID Tagging	0,1	Binary Variable
Fall RFID Tagging	0,1	Binary Variable
CFIA Inspection	0,1	Binary Variable
Program Admin. & Documentation	0,1	Binary Variable

Table 4.4: Endogenous Variable Summary

Endogenous Variable	Equation	Unit
Weaning Weight	$= \text{Base Weight} + \text{GEP Response} * \text{Hormone Implant}$	Pounds/ animal
Calves Weaned	$= \# \text{ Brood Cows} * \text{Weaning \%}$	Animals
Total Production	$= \text{Calves Weaned} * \text{Weaning Weight}$	Pounds
Direct Costs	$= (461.94 + 1.72 * \text{Hormone Implant} * \text{Calving Percentage} + 1.48 * \text{Individual ID Tag} * \text{Calving Percentage}) * \# \text{ Brood Cows} + (\text{CFIA Insp. \& Admin} * 433.40)$	\$
Yardage Costs	$= 109.56 * \# \text{ Brood Cows}$	\$
Other Costs	$= 21.34 * \# \text{ Brood Cows}$	\$
Labour Costs	$= ((7.86 + \text{Individual ID Tag} * 0.17 * \text{Calving Rate}) * \# \text{ Brood Cows}) * 24 + (\text{CFIA Insp. \& Admin.} * 2.5) * 24$	\$
Total Costs	$= \text{Direct Costs} + \text{Yardage Costs} + \text{Other Costs} + \text{Labour Costs}$	\$
Break-Even	$= \text{Total Costs} / \text{Total Production}$	\$/pound

Chapter 5 – RESULTS

5.1 Introduction

The scenarios described in Chapter 3 were simulated using the parameterized model described in Chapter 4. Now, the resulting break-even simulations are presented for each of the four scenarios and the BE price under EU certified management. The difference between the break-even values before and after enrollment represents the additional cost of producing calves in line with EU standards. These results are immediately followed by estimates of the annual supply of feeder calves produced within each category. This indicates the potential supply of calves that may be available to enter the EU market channel if producers offered the corresponding premium.

Following the presentation of the static model results is a series of sensitivity analyses. The purpose of this analysis is to reflect the impact that variations in production measures amongst cow-calf operations has on the resulting BE prices. There is a large degree of variability in this industry, so a single static model does not adequately reflect the realistic diversity that is inherent for cow-calf production. Additionally, this analysis demonstrates the impact that slight improvements in management, leading to increased productivity, can have on BE.

However, the loss in productivity that some producers will experience by foregoing GEP's also affects profits. Therefore, the profit margins for each scenario, as well as EU production, are calculated using varying local feeder calf prices to see how the premium changes in response to market conditions. This section calculates the per-head premium that would need to be offered offset the opportunity cost of selling into the domestic market.

5.2 Simulation Results

5.2.1 Break Even For Compliant Production

The estimated EU compliant BE price for western Canadian cow-calf producers is estimated to be \$1.6525 per pound. This result represents the cost of production when growth enhancing products are not administered, and additional labour is expended for implementing an alternative ID system as well as undergoing CFIA administrative procedures for certification. All of the production scenarios are compared to this BE value, as the cost of production in this model is the same regardless of the practices in place prior to enrollment.

The results for each simulation are summarized in Table 5.1. The BE difference for scenarios A to D is the difference between the base scenario's BE price and that of the EU compliant scenario. This measure quantifies the profitability impact of transitioning from status quo practices to those required for EU certification. A larger difference indicates a larger degree of change to the existing management practices and productivity level to meet certification requirements. If a producer had already implemented a practice required under the EU program prior to enrolling, the cost of that practice is not included.

Table 5.1: Summary of Results

Scenario	BE (\$/lb)	BE Difference (\$/lb)	BE Difference (\$/calf)
EU Compliant	\$1.6559	-	-
Scenario A Base	\$1.5922	\$0.0637	\$34.78
Scenario B Base	\$1.6025	\$0.0534	\$29.16
Scenario C Base	\$1.6414	\$0.0145	\$7.92
Scenario D Base	\$1.6520	\$0.0039	\$2.13

5.2.2 Scenario A

Scenario A represents a ‘least compliant’ producer, meaning that they administer growth enhancing products to their calves and do not have alternative ID protocols already in place. Thus, amongst all scenarios simulated, this one has the smallest base BE of \$1.59 per pound. As the producers in this group take advantage of growth enhancing products and have no additional labour expenses associated with alternative tagging, for them to have the lowest BE is expected. As a result of this low initial case BE, the per-pound BE increase for supplying to the EU marketing channel is largest for scenario A, as these producers need to make the largest changes to their production practices and experience a decline in productivity. In other words, for these producers to continue earning a normal profit, they would need to receive 6.37 cents per pound more than they were initially.

The fourth column shows how this per-pound premium translates into a per-calf premium. The value for scenario A, \$34.78¹⁵, represents the additional revenue that the producer would need to earn over what they would make selling a lighter calf at their initial break-even price. Recall that for scenario A the producer must forego the use of GEPs to become EU compliant, resulting in lighter average weaning weights. If they were to meet the elements of EU compliance while still earning their initial BE price of \$1.5922 per pound, they would incur a loss of \$34.78 per calf as a result of increased production costs and reduced productivity. Therefore, to maintain a zero profit or to continue breaking even, they would need to earn this premium for each enrolled calf. In the context of the cow-calf enterprise as a whole, this premium indicates that the producer would need to earn approximately \$8000 more than they would have if earning their initial BE price of \$1.5922 with a lighter weaning weight of 546 pounds to maintain zero profit when switching to EU compliant practices. Although this premium may seem quite large, compared to the total revenue for the calf crop, it amounts to only 4 percent.

5.2.3 Scenario B

Scenario B reflects a ‘partially compliant’ producer that already has an alternative ID system in place, but also implants their calves. Therefore, this group faces a loss of production by meeting the program requirements, but their increase in labour is only related to the CFIA inspection and documentations components, as they are already incurring the cost of an alternative ID system. Therefore, the base BE of \$1.60 per pound for scenario B is slightly larger

¹⁵ This premium can be calculated two ways: $\$0.0637 * 546 \text{ pounds} = \34.78 , or, $\$904.13 - (546 * \$1.5922) = \$34.78$. The value \$904.13 represents the COP per calf in an EU compliant scenario.

than that of A. Scenario B producers would require a smaller premium of 5.34 cents per pound to cover their costs and loss in productivity to maintain normal profits.

The per-calf BE difference shown in the fourth column carries the same meaning for scenario B as it does for scenario A. This value, which can also be considered the premium required to maintain a zero profit level, is estimated to be \$29.16¹⁶ for scenario B producers. Much like scenario A, this premium represents the difference between what a producer would earn with their initial BE price and EU compliant production levels, and what they would need to earn to earn a zero profit once enrolled in the program. In the context of the whole cow-calf enterprise, this premium translates into approximately \$6700 for the entire calf crop.

5.2.4 Scenario C

Scenario C also represents partially compliant producers, but with the requirements they meet being reversed to that of scenario B. In this case, the producers have already elected to forego the hormone implant regardless of their status in the program, but have not implemented alternative ID tagging. Therefore, no difference in production would be observed for this group, but they would face higher labour expenses associated with tagging as well as the CFIA requirements that apply to all other scenarios as well. The base BE for scenario C is \$1.64 per pound, thus the estimated premium required by this group is an additional 1.45 cents per pound over what they earned before to cover their new expenses.

Since this group does not experience a decline in production when switching to EU complaint production, the per-head premium shown in column four is much smaller than for

¹⁶ $\$0.0534 * 546 \text{ pounds} = \29.16 , $\$904.13 - (546 * \$1.6025) = \$29.16$

scenarios A or B. The per-calf premium value in this scenario, \$7.92¹⁷, only reflects the impact that compliance has on production costs as there is no loss in productivity. In the context of the whole cow-calf enterprise, this translates into a premium of approximately \$1823 for the entire calf crop.

5.2.5 Scenario D

This final scenario was structured to represent producers that are in a position of easiest compliance. In other words, these operations would have to undergo the fewest changes to become certified for selling into the EU marketing channel. These producers already have adequate ID protocols in place and will not observe a decline in production as they already have foregone the hormone implant. Essentially they only need to undergo CFIA inspection and documentation procedures to enroll in the program. Therefore, it is unsurprising that the premium estimated for this group is very small, at 0.39 cents per pound. The only change to costs in scenario D is associated with CFIA inspection and documentation, which is distributed over the entire calf crop. Thus the required premium is quite small for this producer group to cover their additional expenses. Therefore, the per-calf premium shown in column four is also small, at only \$2.13¹⁸. In terms of the entire calf crop, the required premium for these producers is only an additional \$490 in revenue.

5.2.6 Weighted Average Sensitivity Analysis

As briefly discussed in Section 4.1, there exists some disparity between the expenses reported by the Saskatchewan and Alberta COP surveys. Therefore, taking a weighted average

¹⁷ $\$0.0145 * 546 \text{ pounds} = \7.92 , $\$904.13 - (546 * \$1.6414) = \$7.92$

¹⁸ $\$0.0039 * 546 = \2.13 , $\$904.13 - (546 * \$1.6520) = \$2.13$

approach to combining these data sets could result in inaccurate estimates of the true population parameters. To address the issue of using a weighted average approach to combining Saskatchewan and Alberta COP data, additional analysis was conducted to examine the possible range of variations from the weighted average used in subsequent analysis. The results I present in the previous section were simulated again, using Saskatchewan and Alberta data exclusively, and compared to the results achieved with a weighted average between the two. Shown in Appendix D, it can be observed that using either provinces' COP alone in the model results in a maximum 6 percent deviation from the weighted average results. Since the possible range of resulting estimates based on the available COP data is small, the weighted average approach will stand.

5.2.7 Supply of EU Certified Cattle

In addition to estimating premium requirements for procuring EU certified calves, another objective of this research is to estimate the supply capacity available for the EU market channel in western Canada. As the COP analysis was restricted to Alberta and Saskatchewan, so too will be the supply estimations. Between these two provinces there are over 2.6 million beef cows, which reside on operations that would fit into one of the four scenario groups defined (Statistics Canada, 2014). Therefore, the supply capacity for the EU market channel within each category will be estimated using adoption rate data for the management practices of interest. In other words, these estimates suggest the potential supply of calves that could be available in response to one of the four premium offerings calculated.

In western Canada, 93 percent of producers maintain individual calf ID records, and 24 percent implant their calves (Manglai, 2016; WBDC, 2015). For this analysis it will be assumed

that there is no correlation between these adoption rates and herd size. Although there is some research which suggests there may be a relationship between herd size and adoption of various technologies or management practices, there is not adequate data available to quantify this relationship in western Canada (Deblitz and Dhuyvetter, 2013; Mangali, 2016; Nehring et al., 2014). This issue, in combination with a desire to refrain from overly manipulating the data, leads to treating the adoption rate data as if it has no correlation to herd size. Thus, using the aforementioned adoption rate data, the estimated portion of calves raised within each management scenario is summarized in Table 5.2.

Table 5.2: Supply of Calves

Scenario	Portion of Calves	Number of Calves Produced
A	1.68%	38,888
B	22.32%	516,654
C	5.32%	123,145
D	70.68%	1,636,072

The values in column 2 of Table 5.2, the portion of calves raised within each category, were calculated by multiplying the adoption rates of the practices associated with that scenario. For example, scenario A's portion was calculated by multiplying 7 percent, the percentage of producers that do not maintain individual IDs for their calves, by 24 percent, the percentage of producers that implant their calves. The resulting portion for this scenario, 1.68 percent, was then multiplied by the beef cow inventory for Alberta and Saskatchewan, 2,654,540 and a weaning rate of 87.2 percent to get an estimate of the number of calves produced each year under these practices in the third column. The proportions for each scenario were calculated in this manner.

Recall that over five years, Canadian beef producers will gain duty-free market access into the EU for 64,950 tonnes (carcass weight equivalent) once the CETA comes into force. To fill this quota, a minimum of 157 000 certified cattle have to be produced. In reality, this supply may actually need to be much higher since not all cuts in the carcass may be imported by the EU. However, the supply estimates in Table 5.2 suggest that filling this quota is certainly possible by the scenario D producers in Saskatchewan and Alberta. Since this group has the greatest ease of compliance, the large supply of beef calves raised by them bodes well for the ability of western Canada to participate in the EU marketing channel.

5.3 Production Sensitivity Analysis

One advantage of using a systems dynamics methodology is the ease by which sensitivity analysis can be conducted. The Vensim program used for modelling includes a ‘Synthesim’ function that allows the value of exogenous variables to be altered and the impacts simultaneously quantified for all variables in the system. Thus, for purposes of sensitivity analysis, the values of production variables can be altered and the subsequent impacts on the EU compliant production BE can be immediately quantified.

As motivated throughout the literature review, several production measures can vary widely between operations. Furthermore, biological performance indicators are found to have a significant influence on profitability when comparing producers operating within a similar climate (Short, 2001). This could be related to many factors, such as the type of feed stuff used, the genetic potential of the cattle, technologies used and management ability (Short, 2001; Nehring et al., 2014). Due to these variations between producers, using a single, static model for estimating the cost of compliance offers results that apply very narrowly. Thus, the purpose of

this section is to gauge the sensitivity of BE to changes in the exogenous variables. Not only does this offer a broader view of the possible farm-level impacts of entering the EU marketing channel, but it also may indicate strategies by which producers could use to make the cost impacts of entering the EU market less severe.

5.3.1 Weaning Weight

Evidence of a relationship between higher weaning weights and improved economic performance has been observed in western Canada, thus weaning weight is a variable of interest for sensitivity analysis (AAF, 2016). The initial results presented in Table 5.1 reflect a single base weaning weight, 546 pounds, but in reality this measure will vary amongst cow-calf producers as calves are often weaned at a range of 450 to 700 pounds (CBB and NCBA, 2009).

Additionally this is a performance indicator that can be improved, to a slight degree, without having substantial impacts on the overall cost of production. Low-cost strategies such as weaning later, cross-breeding and selectively culling later calving cows can be implemented to increase average weaning weight (Johnston, 2017). Thus, it is logical to simulate small increases in weaning weight while holding production costs constant to determine their impact on break-even. Large changes to weaning weights may necessitate substantial changes to management strategies, and as a result production costs. Therefore only small deviations of 5 to 25 pounds, less than 5 percent of the initial value, from the base weight are simulated for this sensitivity analysis. The EU compliant BE price in response to these variations in base weaning weight are presented in Table 5.3. These results suggest that increasing weaning weight by approximately 25 pounds can reduce the BE price by 4 cents per pound.

Table 5.3: Base Weaning Weight Sensitivity

Base Weaning Weight	EU Compliant BE (\$/lb)
546	\$1.6559
550	\$1.6439
555	\$1.6291
560	\$1.6145

5.3.2 Weaning Percentage

Another biological performance indicator of interest for sensitivity analysis is weaning percentage. The initial parameter value used for this variable was 87.2 percent, meaning this portion of the cows in the herd will yield a calf at the end of the production season. As is the case with weaning weight, AAF (2016) data has suggested that low cost producers in tend to have higher than average weaning percentages in western Canada. This is a logical conclusion, as increasing the units of output over which costs are distributed will result in lower per-unit costs if the total costs do not increase.

Again, production costs will be held constant as varying levels of weaning percentages are simulated. Strategies, such as carefully controlling the breeding period, proper nutrition management and culling open brood cattle can improve this percentage while having a small effect on production costs (Dyer and Knight, 2013). Therefore, small deviations in this variable can be simulated without a simultaneous change in production costs. For large changes in weaning percentage, it is likely that a significant change in management would need to occur,

which would influence production costs. Therefore, weaning percentages ranging from 82.8 percent to 91.6 percent are used for this sensitivity analysis, representing deviations of only 5 percent from the initial parameter value of 87.2 percent. As is shown in Table 5.4, a 5 percent increase from the initial parameter value of 87.2 percent is associated with a 8 cent per pound decline in BE, whereas a 5 percent decrease can result in an 9 cent higher BE.

Table 5.4: Weaning Percentage Sensitivity

Weaning Percentage	EU Compliant BE (\$/lb)
82.8%	\$1.7439
85.0%	\$1.6988
87.2%	\$1.6559
89.4%	\$1.6152
91.6%*	\$1.5768
*For this simulation run, the calving percentage was increased to 95% from 90.9%, as it is not possible to wean more calves than are born live. This variable only interacts with the tagging expenses, so has a small impact on results.	

5.3.3 Implant Response

Several factors can affect the growth response of implanted calves. Proper administration and adequate nutrition are both necessary to realize the full benefit of implanting (Stewart, 2013). In addition to these factors, the genetic growth potential of the calves can also interact with GEPs, as inherently higher growth rate cattle will tend to exhibit a greater response to GEPs (Gadberry, 2015). As these are factors that can vary between operations, there exists variations in the response to GEPs amongst cattle. The static value for implant response used in the model

generates results that apply narrowly, so this is the third variable which undergoes sensitivity analysis.

The response of suckling beef calves to implants has been shown to range from 10 to 30 pounds in additional weaning weight, or 3 to 8 percent (AAF, 2008; Gadberry, 2015; Lawrence and Ibubaru, 2007; Selk, 1997; Stewart, 2013). The parameter value used for initial analysis, 18 pounds, was based on the meta-analysis conducted by Selk. In reality, this response can vary widely depending on the aforementioned factors. Therefore the resulting BE for scenario A, shown in Table 5.5, is re-simulated using an implant response range of 10-30 pounds.

Table 5.5: Implant Response Sensitivity

Implant Response	Scenario A BE (\$/lb)
10 lbs	\$1.6151
14 lbs	\$1.6036
18 lbs	\$1.5922
22 lbs	\$1.5810
26 lbs	\$1.5699
30 lbs	\$1.5590

5.4 Price Sensitivity Analysis

The purpose of this section is to quantify the trade-off that cow-calf producers face when deciding to sell into the EU marketing channel or through conventional, domestic channels. Thus far, the results presented have only concerned the break-even price required by producers to earn

a normal profit. In reality, cow-calf producers are price-takers who may experience prices higher or lower than this BE value, resulting in lesser or greater profits. Additionally, the BE calculation only takes into account the influence of weaning weight on per-unit production costs, with its influence on the revenue for the animal not being incorporated into the model. This is not a shortcoming of the model, it was intentionally designed to hold profit constant at a value of zero as the revenue potential following implementation of the CETA is unknown at this point.

However, the trade-off between selling domestically through conventional marketing channels versus through the EU channel can still be quantified using local calf price data. The rationale for this exercise is to determine the per-head premium that would need to be offered to producers for their enrollment in the program to make them indifferent between status quo and certified production at various domestic prices. Since enrolling affects the productivity of producers that use GEPs, larger premiums are needed to offset the loss in production as domestic prices climb higher.

In the past decade, Alberta feeder calf prices have ranged from less than \$1 to over \$3 per pound (Statistics Canada, 2017). Using this price range, the profit margin per calf will be calculated using Equation 12 for each scenario under status quo and compared to the profit margin for compliant production at the same price. The difference between these profit margins is equivalent to the premium a producer would need to earn, above the market price, to be no worse off by switching to EU compliant practices and selling into that channel.

$$\textit{Profit Margin per Head} = (\textit{Market Price} - \textit{BE}) * \textit{Weaning Weight} \quad (12)$$

The resulting calculations are presented in Table 5.6. As can be observed, the premium for production scenarios A and B change in response to market conditions, whereas C and D do not. The reason for this distinction is the fact that scenarios A and B use GEPs, so revenue declines for these groups when they switch to compliant production, the effect of which is exacerbated by higher market prices. Scenarios C and D do not experience a difference in productivity, so the resulting premiums only reflect the difference in production costs per calf between the status quo and enrollment.

Table 5.6: Profit Margin Sensitivity

Market Price	EU Certified Margin	Premium A	Premium B	Premium C	Premium D
\$1/lb	-\$358.12	\$24.12	\$18.31	\$7.92	\$2.13
\$2/lb	\$187.88	\$42.12	\$36.31	\$7.92	\$2.13
\$3/lb	\$733.88	\$60.12	\$54.31	\$7.92	\$2.13

5.5 Chapter Summary

The purpose of this chapter was to present the results of the simulations using the model built in Chapter 4. They suggest that the impact of enrolling in the EU program ranges from an addition to BE of 6 cents per pound, down to 0.05 cents per pound. For each scenario simulated, an estimate of feeder calves supplied annually was made using adoption rate data for the practices of concern. Scenario A, which has the largest compliance costs, has the smallest supply of cattle at only 1.68 percent. The second largest compliance costs as well as the second largest

supply of cattle was scenario B. Interestingly, scenario D has the largest supply of cattle and faces the smallest cost changes for enrolling in the program.

Next, a series of sensitivity analyses were conducted as a means for better reflecting the large degrees of production variability amongst cow-calf operations. These estimates also quantify the impact that small improvements in productivity can have on COP. For example, an increase in base weaning weight to 560 pounds decreases the EU certified break even by 4 cents per pound. Similarly for weaning percentage, a 5 percent improvement can reduce the required BE price by 8 cents per pound. For producers that use an implant, an improvement in the response to 30 pounds can reduce their BE by 3 cents per pound.

Finally, the revenue implications of foregoing conventional marketing channels to enter the EU program were quantified. Essentially, the purpose of doing so was to quantify the premium needed for producers to be indifferent between conventional and EU marketing channels. For producers that implant, the premium ranged from \$18.31 to \$60.12 to offset both increased labour expenses and loss in productivity for entering the EU market. For those that already forego GEPs, their premium did not vary in response to market prices, as they do not face a loss in productivity so only the additional costs need to be covered.

Chapter 6 – SUMMARY AND CONCLUSIONS

6.1 Summary

The objective of this research was to estimate the farm level economic impacts for western Canadian cow-calf producers becoming EU compliant. As there is a large degree of heterogeneity in this sector, several scenarios which represent operations with different production practices that affect their ease of compliance with EU regulations were analysed. In addition to estimating premium requirements, another objective was to estimate the supply of calves within each group.

Increased access to the EU market with the implementation of the CETA may be a profitable opportunity for the Canadian beef industry, but there are certain costs imposed on producers that wish to participate. For cow-calf producers, use of any growth enhancing products on cattle destined for the EU is strictly prohibited. To ensure this protocol is being followed, the CFIA has in place a program for certifying GEP free beef. Essentially, this program relies on a combination of approved veterinarian inspections, identification procedures and documentation to gain adequate assurance that the producer has complied with the no GEP stipulation. Therefore, the costs of compliance are imposed on cow-calf producers in two ways: a loss of productivity when GEPs are foregone and additional labour to complete the administrative requirements for enrollment in the program.

The premium required for EU certified production to maintain normal profit was estimated by simulating the BE price under typical production practices as well as under program compliant practices and calculating the difference between them. The first step in running these simulations was the construction of a conceptual model that mapped out the relationship between

various drivers of production costs and their impact on BE. Interacted with these drivers were the various elements of compliance for enrolling in the EU program so that a conceptual framework for how they ultimately can influence BE could be laid out.

Next, the conceptual framework was parameterized to develop a working model. The primary sources of information were cost of production studies published by Alberta Agriculture and Forestry and the Western Beef Development Centre, which provide an overview of typical production costs for Alberta and Saskatchewan cow-calf producers. Using data from a variety of sources, these COPs were incorporated into the model and manipulated to reflect production costs before and after EU compliance. The management decisions regarding EU production practices were included in the model as binary variables, taking on values of 0 or 1, depending the use of the practice that variable represented. The purpose of these binary variables was to turn additive parts of an equation in the model ‘on’ or ‘off’, so that BE outcomes in response to varying management practices could be simulated using a single model.

Finally, the resulting BE for scenarios A, B, C and D could be estimated. Scenario A, which represented the least compliant producers that use GEPs and have minimal ID procedures in place, required the largest premium of \$6.37 per hundredweight. The second highest premium was for scenario B, in which producers used GEPs but had adequate ID systems in place, at \$5.34 per hundredweight. Scenario C represented producers that had already foregone GEPs but needed to upgrade their ID practices, resulting in a premium of \$1.45 per hundredweight. All of these scenarios had to take on additional costs of CFIA inspection and documentation, as well as the aforementioned changes to their management routines. Scenario D was distinct from the others in the sense that the operation it represented already had most of the necessary practices in

place to be an EU compliant producer, needing only to complete the CFIA administrative tasks to become officially certified. Thus, the required premium for this group was very small at only \$0.4 per hundredweight. Interestingly, scenario D was also estimated to have the largest supply capacity, with 70.68 percent of operations conforming to the practices associated with this group.

These results next underwent sensitivity analyses to offer a range of results that may better reflect the heterogeneity amongst cow-calf producers, while also demonstrating the impact that improvements in productivity can have on BE. Also undergoing sensitivity analysis was the per-head premium level for each scenario in response to local market prices. The purpose was to relax the normal profit constraint, as market prices can range widely and producers must make the decision to produce and sell into domestic conventional markets or the EU channel. This also served the purpose of quantifying the opportunity costs associated with foregoing GEPs at a range of market prices.

6.2 Limitations

The results of this analysis may not directly apply to an individual producer's situation. Since the model was parameterized using data aggregated across two provinces, caution must be used when making linkages between the results presented here and actual production outcomes. Within these provinces there exists climatic variation, which can be an influential factor in determining COP. If adequate data was available, which disaggregated the production regions within these provinces, results that applied more accurately to producers may have been generated. These results are also highly aggregated with respect to other important drivers of production costs, including herd size. As discussed in the literature review, cow-calf production can exhibit to economies of size. However, a single average herd size was used to parameterize

the model, the result of which is a model that cannot effectively reflect the relationship between economies of size and production costs. The highly aggregated nature of the data available for parametrizing this model also means that other potential influencers of COP or productivity, such as breed type, management ability or adoption of technologies that were not of direct interest, and their impacts could not be effectively represented. Therefore, individual producers likely have COP or productivity outcomes that may differ from the ones presented here.

In addition to the highly aggregated nature of the COP data, the results are also limited by the small sample sizes from which they were derived. The WBDC survey included 22 producers, whereas the AAF surveys typically include approximately 30 observations. Therefore, these results represent a very small portion of cow-calf operations, which limits their applicability to a wide range individual producers. This research was intended to provide a framework by which the farm-level economic impacts of entering differentiated marketing channels and estimate a general cost which compliance with EU regulations may place on the western Canadian cow-calf production segment of the supply chain. However, the results are not intended to directly estimate these costs for an individual producer looking to enter the EU channel.

Also potentially arising from small sample sizes for the COP surveys could be biased estimates. As participation in these surveys is voluntary, there may exist some selection bias. In other words, producers with certain characteristics may be more inclined to participate in these surveys than others, which could bias the resulting estimates. For example the average herd size reported by these surveys, 354 for Saskatchewan and 198 for Alberta, is much larger than the average herd size of approximately 80 head in these provinces as reported in the census data. This suggests that perhaps producers with larger than average herds tend to participate in the

surveys more frequently, which may place a downward bias on the estimates because of the influence that economies of size can have on production costs. Therefore, the possible presence of bias in the survey data used to parameterize the model means that the results presented here may not be truly representative of a population average.

The supply estimates also need to be interpreted with caution. These calculations were made on the assumption that the adoption rate for GEPs was independent of the adoption rate for individual ID tagging, and vice versa. However, in reality there may be some correlation or relationship between the adoption rates of these practices. In other words, managers that adopt technologies such as GEPs may also be more likely to adopt improved ID and record-keeping practices as well. However, the adoption rates were taken from different studies, so finding cross-correlations between them was not possible and this issue could not be addressed. Furthermore, the adoption rate of these practices may also be related to herd size, as was indicated by Nehring et al. (2014). If this is the case, the quantities of cattle estimated within each production category may not be accurate. For example, if the adoption of GEPs is positively related to herd size, then the supply associated with scenarios A and B would be smaller than estimated here. However, the herd sizes associated with adoption rate for western Canada were not reported, so it was not possible to correct for these possible correlations. The supply estimates must also be interpreted cautiously, as they may not be accurate for the aforementioned reasons.

6.3 Conclusions

The findings of this research suggest that entering differentiated beef marketing channels, such as the EU certified GEP-free channel, may be an economically viable decision for some

cow-calf producers. As there is a large degree of variability between producers in the cow-calf segment, enrolling in this program can be achieved at little additional cost, or quite expensive, depending on the production practices already in place. For the 76 percent of cow-calf producers that already choose to forego GEPs, entering the EU channel may enable them to earn a premium for voluntarily foregoing profit-enhancing practices. Especially in this case, differentiated marketing could compensate producers for lost productivity when electing to not implant. Thus, for the 70.68 percent of producers in western Canada that fell into the easy compliance category D, pursuing the EU marketing channel may be an attractive opportunity.

However, the fact that the rest of the supply chain needs to also enter the channel before cow-calf producers could benefit from this trade opportunity should not be overlooked. A premium may only be earned for EU certified calves if a buyer willing to pay it is accessed. Since there are barriers to entering the EU market at each step of the Canadian beef supply chain, it is not a certainty that downstream firms will enter the EU channel and demand certified calves. Much like the results of this thesis have indicated for the cow-calf segment, the additional costs presented by achieving EU compliance must be outweighed by an adequate premium to make the export opportunities presented by the CETA profitable for all parts of the supply chain. Whether or not the Canadian beef supply chain responds to increased EU market access will depend on the price that may be fetched in that market and if it is large enough that an adequate premium may be offered to each segment of the supply chain. The research presented here offers insight into the premium that may be required by the first stage of the market channel to stimulate a supply response. As the results suggest, this premium may not need to be large for some producers to be profitable marketing in the differentiated EU channel. This may, however, not be case for other segments of Canada's beef supply chain.

Beyond the EU channel, producers may be well advised to explore other differentiated marketing or production verification opportunities, depending on the management practices they already have in place. For example, the Verified Beef Production Plus¹⁹ (VBP+) program could be another avenue. In this program, producers undergo an auditing process to verify high standards for food safety, animal care and environmental stewardship with respect to raising their cattle. Many of the practices required under this program, such as monitoring for illness or properly managing grasslands, are already voluntarily being followed by cow-calf producers. Therefore, complying with this program would not present especially large costs or changes to everyday operation for several producers. Much like the results of this research suggest, there may be a subset of producers that could enroll in the VBP+ certification program without seeing a substantial change to their production costs. Additionally, this program may offer a platform by which sources of certified cattle could be identified. As mentioned earlier in chapter 3, procuring certified cattle will not likely be practical in the spot market, and having an identified pool of eligible producers could help reduce transaction costs. This could contribute to improving the overall profitability of the EU differentiated beef supply chain for all players.

An important conclusion is that producers should not shy away from differentiated marketing programs. The heterogeneity amongst operations in the cow-calf segment means that there may be a subset of producers that easily fits into the mold set out by any branded or differentiated beef program. Opportunities, such as entering the EU channel, may enable producers to earn price premiums for practices they were following regardless. Pursuing these opportunities may enable producers to employ a new strategy to improve their competitiveness.

¹⁹ Verified Beef Production Plus is a verification program that enables producers to prove implementation of sustainable production practices on their operations to buyers (Verified Beef Production Plus, 2017).

Traditionally beef production has been characterized as a perfectly competitive market, resulting in the reduction of costs being the only strategy to remain competitive when producers were in the position of a price taker. However, the growing prevalence of differentiated beef marketing channels has allowed producers to begin taking steps towards being in a position where they can differentiate their production to gain some power over price determination. Opportunities to compete on product attributes, rather than focusing only on reducing costs, can improve the profitability for firms that may not be able to compete on costs alone. Therefore, cow-calf producers should welcome opportunities to target consumers by implementing certain production practices, rather than viewing consumer demands for certain production attributes as a threat.

Despite the potential benefits of transitioning to a more differentiated beef marketing structure, there still exists institutional constraints that will slow the process of doing so. Currently the Canadian beef supply chain is set up for an undifferentiated commodity marketing structure, and would need to undergo a major reorganization to become more vertically coordinated (Brocklebank, 2004). On the horizon, the western Canadian beef industry is anticipated to gain increased capacity for processing niche or differentiated beef products with the opening up of the Harmony Beef plant near Calgary (Kienlen, 2017; Duckworth, 2017b). The intention of this plant is to enter into niche markets for beef, including processing for the EU market. Thus, the structural rigidity of Canadian beef processors, which are traditionally set up for large quantity and little differentiation, may be alleviated.

However, the commodity beef channel is not anticipated to completely give way to a more coordinated and differentiated channel any time soon. This means that generic, commodity beef production that does not call for any special production attributes will continue to play an

important role in the marketing of beef cattle. In this paradigm, low cost and high efficiency production is the key strategy for improving competitiveness. For producers that remain in the generic beef marketing channel, foregoing the use of GEPs carries a very high opportunity cost. As the market price sensitivity analysis results show, producers may need to be paid premiums of \$60 per head to compensate for the productivity losses associated with foregoing GEP usage. The implication of this finding is that producers who remain in the commodity market channel should be employing this simple procedure to maximize the return on their cattle, as they are not being compensated for their production losses.

The Canadian beef industry should continue to pursue opportunities to enter new markets, and foster the development of differentiated marketing channels. By working through the process of quantifying the cow-calf level impact of accessing the EU market, this research demonstrates that refocusing on certain production attributes can be relatively low cost for some producers. As this segment of the supply chain tends to be very heterogeneous, there is likely to exist a subset of producers that can easily transition into most niche marketing channels and begin to earn a premium for practices they already employ on their operations. Being able to target alternative markets, in addition to the traditional commodity beef channel, provides producers more opportunities to compete with strategies other than reducing costs. For those producers that happen to be highly cost efficient, it is likely that the generic commodity beef channel will continue to exist in some capacity. However, working towards increasing the marketing opportunities available to cow-calf producers can improve the overall economic health of the industry.

6.4 Areas for Further Research

This research focused on the quantifying the cost of production impacts for cow-calf producers that enter the EU market channel, serving as a basis for evaluating the trade-off between entering this channel and remaining in conventional ones. Thus, the next logical steps for enquiry would be to examine other factors which may influence the decision to enter new marketing channels, including the EU. Factors besides profitability, such as marketing preferences or ethical concerns over GEP usage, may also influence a producer's decision. Information on the characteristics of producers that would be more willing to participate in the EU program would also help downstream firms find potential supply sources of certified cattle and develop a marketing arrangement for their procurement.

Another direction for research extend from this thesis is to conduct similar analysis for down-stream firms in the Canadian beef supply chain. The costs of compliance for enrolling in the EU program could be determined for backgrounding, feedlot and packing operations that also face process constraints if they wish to enter the EU market. By determining the costs for each stage of the supply chain, the wholesale price that Canadian beef must fetch in the EU to be profitable can be estimated. This price estimate can then be used as starting point for researching the willingness to pay for Canadian beef amongst EU consumers, and offer much needed information to potential Canadian beef marketers expanding to the EU. Overall, the cost estimates for cow-calf producers developed here contribute to answering a larger question regarding the economic viability of selling Canadian beef in the EU once the CETA enables greater access to that market.

REFERENCES

- Alberta Agriculture and Food (AAF). 2008. *The Beef Cow-Calf Manual*. Agdex publication 420/10.
- Alberta Agriculture and Forestry (AAF). 2015. Traceability: Beef Cattle. [http://www1.agric.gov.ab.ca/\\$Department/deptdocs.nsf/all/trace14202](http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/trace14202). (Last Accessed May 3, 2017).
- Alberta Agriculture and Forestry (AAF). 2016. AgriProfit\$ Multi-Year Economic, Productive & Financial Performance of Alberta Cow/Calf Operations. Retrieved from: [http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/econ8479](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/econ8479)
- Alberta Agriculture and Rural Development (AARD). 2011. AgriProfit\$ Economic, Productive & Financial Performance of Alberta Cow/Calf Operations. Retrieved from: [http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/econ8479](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/econ8479)
- Alberta Cattle Feeders Association (ACFA). n.d. Feedlots 101: everything you need to know about cattle feeding in Alberta. Retrieved from: <http://www.cattlefeeders.ca/the-feed/feedlots-101-everything-you-need-to-know-about-cattle-feeding-in-alberta/?#> (Accessed Feb 28, 2017)
- Angirasa, Aditi K., C. Richard Shumway and T.C. Cartwright. 1985. Simulating Differences in Net Returns from Beef Production Under Alternative Forage Systems and Management Practices. *Agricultural Systems*, 17: 99-116. DOI: 10.1016/0308-521X(85)90016-2
- Bartlett, E.T, Gary R. Evans and R.E. Bement. 1974. A Serial Optimization Model for Ranch Management. *Journal of Range Management*, 27, (3): 233-239. URL: <http://www.jstor.org/stable/3897041>.
- Biswas, Basudeb, John R. Lacey, John P. Workman and Francis H. Siddoway. 1984. Profit Maximization as a Management Goal on Southeastern Montana Ranches. *Western Journal of Agricultural Economics*, 9, 1: 186-194. Stable URL: <http://www.jstor.org/stable/40987648>
- Bredahl, Maury E. and Leonie A. Marks. 2012. Influence of Management on Ontario Beef Operation Margins. Presented at the Agricultural and Applied Economics Association 2012 Annual Meeting, Seattle, Washington. URL: <http://purl.umn.edu/126949>.
- Brocklebank, Andrea M. 2004. Supply Chain Coordination in the Canadian Beef Industry: Assessing the Opportunities and Constraints. MSc. Thesis, University of Saskatchewan.
- Buchanan-Smith, Jock. 2016. Optimizing Feedlot Efficiency. *Beef Canada Research Council*. Retrieved from: <http://www.beefresearch.ca/research-topic.cfm/optimizing-feedlot-feed-efficiency-8>. (Accessed August 8th, 2016).

- Campbell, John R., M. Douglas Kenealy and Karen L. Campbell. 2009. *Animal Sciences: The Biology, Care and Productions of Domestic Animals*, 4th Edition. Waveland Press: Long Grove Illinois. p: 211
- Canadian Animal Health Institute. 2003. Hormones: A Safe, Effective Production Tool for the Canadian Beef Industry. Retrieved Aug. 4, 2016 from: <http://www.cahi-icsa.ca/food-animal-health/hormones.aspx>
- Canadian Cattlemen's Association. August 2014. CCA applauds announcement of complete CETA text. Retrieved from: <http://www.cattle.ca/news-events/news/view/cca-applauds-announcement-of-complete-ceta-text/>
- Canadian Cattle Identification Agency. 2009. About Us. http://www.canadaid.com/about_us/about_us.html (Accessed March 30, 2017).
- Canadian Food Inspection Agency. 2016. Annex R: The Canadian Program for Certifying Freedom from Growth Enhancing Products (GEPs) for the Export of Beef to the European Union (EU). Retrieved from: <http://www.inspection.gc.ca/food/meat-and-poultry-products/manual-of-procedures/chapter-11/european-union/annex-r/eng/1462942544704/1462942667141>. (Last Accessed May 3, 2017).
- Canadian Meat Council. 2017. International Trade. Retrieved from: <http://www.cmc-cvc.com/en/international-trade> (Accessed Feb. 23, 2017).
- Capper, Judith L. 2012. Is the Grass Always Greener? Comparing the Environmental Impact of Conventional, Natural and Grass-Fed Beef Production Systems. *Animals*, 2: 127-143. DOI:10.3390/ani2020127
- Capper, J.L. and D.J. Hayes. 2012. The environmental and economic impact of removing growth-enhancing technologies from U.S. beef production. *Journal of Animal Science*, 90: 3527–3537. DOI:10.2527/jas2011-4870.
- Cattlemen's Beef Board and National Cattlemen's Beef Association. 2009. Modern Beef Production. Retrieved from <http://www.explorebeef.org/factsheets.aspx>.
- Centner, T.J., J.C. Alvey and A.M. Stelzleni. 2014. Beta agonists in livestock feed: Status, health concerns, and international trade. *American Journal of Animal Science*, 92:4234-4240. Retrieved from: <http://www.ads.uga.edu/documents/Betaagonistsinlivestockfeed.pdf>. (Accessed August 4th, 2016)
- Commission of the European Communities. 1987. *The Agricultural Situation in the Community 1986 Report*. Luxembourg: Office for Official Publications of the European Communities.

- Coopridge, K.L., F.M. Mitloehner, T.R. Famula, E. Kebreab, Y. Zhao and A.L. Van Eenennaam. 2011. Feedlot efficiency implications on greenhouse gas emissions and sustainability. *Journal of Animal Science*, 89:2643–2656. DOI:10.2527/jas.2010-3539.
- Crosson, P., P.O’Keily, F.P. O’Mara and M. Wallace. 2006. The development of a mathematical model to investigate Irish beef production systems. *Agricultural Systems*, 89: 349-370. DOI: 10.1016/j.agsy.2005.09.008
- D’Aquino, Sandy A. 1974. A Case Study for Optimal Allocation of Range Resources. *Journal of Range Management*, 27, 3: 228-233. URL: <http://www.jstor.org/stable/3897040>.
- Debertin, David L. 2012. *Agricultural Production Economics, Second Edition*. CreateSpace Independent Publishing Platform. Available at: http://uknowledge.uky.edu/agecon_textbooks/1/
- Deblitz, Claus and Kevin Dhuyvetter. 2013. Cost of Production and Competitiveness of Beef Production in Canada, the US, and the EU. *Agribenchmark: Beef and Sheep Network Working Paper Series* (2013/5). Retrieved from: <http://www.agribenchmark.org/beef-and-sheep/publications-and-projects/working-paper-series.html> (Accessed: August 5th, 2016)
- Devereaux, Charan. 2006. Food Fight: The United States, Europe and Trade in Hormone Treated Beef. Case Studies in US Trade Negotiation, Vol. 2. Institute for International Economics. Retrieved from: https://piie.com/publications/chapters_preview/3632/01iie3632.pdf (Accessed August 3, 2016).
- Doren, P.E., C.R. Shumway, M.M. Kothmann and T.C. Cartwright. 1985. An Economic Evaluation of Simulated Biological Production of Beef Cattle. *Journal of Animal Science*, 60, 4: 913-934. DOI: 10.2527/jas1985.604913x
- Duckworth, Barbara. 2017a. Canadian export officials miffed over CETA import regulations. *The Western Producer*, 95(9):67 (March 2nd)
- Duckworth, Barbara. 2017b. Harmony Beef to Reopen. *The Western Producer*. Retrieved from: <http://www.producer.com/2017/02/harmony-beef-to-reopen/>. (Last Accessed July 27, 2017)
- Dyer, Ted G., and Carole H. Knight. 2013. How to Improve Your Percent Calf Crop. University of Georgia Cooperative Extension Circular 672. Retrieved from: <http://extension.uga.edu/publications/detail.cfm?number=C672>
- Faintuck, Rick (CFIA approved veterinarian, Stockyards Veterinary Services) in discussion with the author, April 20th, 2017.

- Fara, G.M., G. Del Corvo, S. Bernuzzi, A. Bigatello, C. Di Pietro, S. Scaglioni and G. Chiumello. 1979. The Epidemic of Breast Enlargement in an Italian School. *The Lancet*, 314(8137):295-297. [http://dx.doi.org/10.1016/S0140-6736\(79\)90304-0](http://dx.doi.org/10.1016/S0140-6736(79)90304-0).
- Featherstone, Allen M., Michael R. Langemeier, and Mohammed Ismet. 1997. A Nonparametric Analysis of Efficiency for a Sample of Kansas Beef Cow Farms. *Journal of Agricultural and Applied Economics*, 29, 1: 175-184. URL: <http://purl.umn.edu/15547>.
- Fenton, Kent (CFIA approved veterinarian, Alberta Feedlot Health Management Services) in personal discussion, April 26, 2017.
- Fernández, M.I. and B.W. Woodward. 1999. Comparison of conventional and organic beef production systems I. feedlot performance and production costs. *Livestock Production Science*, 61: 213–223. [http://dx.doi.org/10.1016/S0301-6226\(99\)00070-6](http://dx.doi.org/10.1016/S0301-6226(99)00070-6)
- Gadberry, Shane. 2015. Growth Implants for Suckling and Growing Beef Cattle. University of Arkansas Extension Publication FSA 3019. Retrieved from: <https://www.uaex.edu/publications/PDF/FSA-3019.pdf>
- Galyean, Michael L., Christian Ponce and Jennifer Schutz. 2011. The future of beef production in North America. *Animal Frontiers*, 1(2): 29-36. DOI:10.2527/af.2011-0013
- Global Trade Atlas. 2017. Canada Export to EU, Commodity 02: Meat and Edible Meat Offal.
- Government of Canada. 2016. Agreement overview. Retrieved Nov. 7, 2016 from: <http://www.international.gc.ca/trade-commerce/trade-agreements-accords-commerciaux/agr-acc/ceta-aecg/overview-aperçu.aspx?lang=eng>.
- Hagel, Jason (Manager, EU certified cow-calf operation) in personal discussion, April 27, 2017.
- Hays, Fred. 2010. Traceability Costs for Alberta's Cow-Calf Sector. Alberta Beef Producers Publication. (Available from: <http://www.albertabeef.org/page/policy-regulations>.)
- Holland, Rob, Dwight Loveday, and Kevin Ferguson. 2014. How Much Meat to Expect from a Beef Carcass. University of Tennessee Institute of Agriculture Extension Publication no.1822.
- Huffstutter, P.J. and Tom Polansek. 2013. Special Report: Lost hooves, dead cattle before Merck halted Zilmax sales. Reuters, December 30, 2013. Retrieved from: <http://www.reuters.com/article/us-zilmax-merck-cattle-special-report-idUSBRE9BT0NV20131230> (Accessed August 24, 2016)
- Hughes, Harlan. 2001. The Changing Market Structure For The American Beef Industry. Paper presented at Western Animal Science Symposium entitled "Using Science and Marketing in Producing and Delivering Value Added Products for the Consumer" Bozeman, Montana June 20, 2001

- Joandet, G.E. and T.C. Cartwright. 1975. Modelling Beef Production Systems. *Journal of Animal Science*, 41, 4:1238-1246. DOI: 10.2527/jas1975.4141238x.
- Johnson, Bradley and Beckett, Jon. 2014. Application of Growth Enhancing Compounds in Modern Beef Production; Executive Summary. American Meat Association Reference Paper (September 2014). Retrieved from: <http://www.meatscience.org/publications-resources/white-papers/docs/default-source/publications-resources/white-papers/application-of-growth-enhancing-compounds-in-modern-beef-production-2015-final>. (Accessed: August 8th, 2016).
- Johnston, Gene. 2017. Tips for Adding 50 Pounds to Weaning Weights. Successful Farming. <http://www.agriculture.com/livestock/cattle/tips-for-adding-50-pounds-to-weaning-weights> (Accessed May 2, 2017).
- Jones, Rodney. 2000. Costs, Distribution of Costs and Factors Influencing Profitability in Cow-Calf Production. Research Institute on Livestock Pricing Agricultural and Applied Economics Research Bulletin 3-2000. Retrieved from: http://www.naiber.org/publications.html#Beef_Demand_&_Economics.
- Joseph, Elizabeth K. 2013. Current Production Practices, Factors Leading to Adoption of Production Practices and Technologies, and Preferences for Receiving Information of Beef Cattle Producers of the Three Regions of North Carolina. MSc. Thesis, North Carolina State University.
- Kahn, Hava E. 1982. The development of a simulation model and its use in the evaluation of cattle production systems. PhD Thesis. University of Reading.
- Kahn, Hava E. and A. R. Lehrer. 1984. A Dynamic Model for the Simulation of Cattle Herd Production Systems: Part 3 Reproductive Performance of Beef Cows. *Agricultural Systems* 13: 143-159. [http://dx.doi.org/10.1016/0308-521X\(84\)90068-4](http://dx.doi.org/10.1016/0308-521X(84)90068-4)
- Kahn, Hava E. and C.R.W. Spedding. 1983. A Dynamic Model for the Simulation of Cattle Herd Production Systems: Part 1-General Description and the Effects of Simulation Techniques on Model Results. *Agricultural Systems*, 12: 101-111. DOI: 10.1016/0308-521X(83)90041-0
- Kahn, Hava E. and C.R.W. Spedding. 1984. A Dynamic Model for the Simulation of Cattle Herd Production Systems: 2-An Investigation of Various Factors Influencing the Voluntary Intake of Dry Matter and the Use of the Model in Their Validation. *Agricultural Systems*, 13: 63-82. DOI: 10.1016/0308-521X(84)90029-5
- Keinlen, Alexis. 2017. Harmony Beef Announces Opening Date. *Alberta Farmer Express*. Retrieved from: <https://www.albertafarmexpress.ca/2017/01/31/harmony-beef-announces-february-opening-date/> (Last Accessed July 27, 2017).

- Koong, L.J., R.L. Baldwin and M.J. Ulyatt. 1978. The Application of Systems Analysis and Mathematical Modelling Techniques to Animal Science Research. *Journal of Animal Science 1978 Symposium*: 9-19. DOI: 10.2527/1978.1978Symposium09x.
- Kostelansky, Bruce (CFIA approved veterinarian, Fort McLeod Veterinary Clinic) in personal discussion with the author, April 20th, 2017.
- Langemeier, Michael R., James M. McGrann and John Parker. 1999. Economies of Size in Cow-Calf Production. *Beef Cattle Handbook*. Retrieved from: <http://www.iowabeefcenter.org/beefcattlehandbook.html>.
- Lapple, D. and H. Kelley. 2013. Understanding the uptake of organic farming: Accounting for heterogeneities among Irish farmers. *Ecological Economics*, 88: 11-19. DOI:10.1016/j.ecolecon.2012.12.025
- Larson. 2013. 2012 Saskatchewan Cow-Calf Cost of Production Analysis. Western Beef Development Centre Fact Sheet #2013-02.
- Larson, Kathy (Western Beef Development Centre Economist) in personal correspondence with the author, March 29, 2017.
- Larson, Kathy. Unpublished COP survey data.
- Lastiwka, Grant. 2014. Identification Systems. [http://www1.foragebeef.ca/\\$foragebeef/frgebeef.nsf/all/ccf794](http://www1.foragebeef.ca/$foragebeef/frgebeef.nsf/all/ccf794)
- Lawrence, John D. and Maro A. Ibarburu. 2007. Economic Analysis of Pharmaceutical Technologies in Modern Beef Production. Proceedings of the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. Chicago, IL, April 16-17, 2007
- Leung, C.Y., S.N. Kulshreshtha and W.J. Brown. 1991. *Economies of Size in Beef Cattle Production in Saskatchewan*. Saskatoon, SK: Department of Agricultural Economics, University of Saskatchewan.
- Loewer, Otto J., Edward M. Smith, Gerald Benock, Nelson Gay, Thomas Bridges, Larry Wells. 1980. Dynamic Simulation of Animal Growth and Reproduction. *Transactions of the ASAE*. 23, 1: 131-138. DOI: 10.13031/2013.34539
- Loewer, O.J., E.M. Smith, G. Benock, T.C. Bridges, L. Wells, N. Gay, S. Burgess, L. Springate and D. Debertin. 1981. A Simulation Model for Assessing Alternate Strategies for Beef Production with Land, Energy and Economic Constraints. *Transactions of the ASAE*, 24, 1: 164-173. DOI: 10.13031/2013.34218.
- McEachern, M.G. and J. Willock. 2004 Producers and consumers of organic meat. *British Food Journal* 106(7): 534 – 552. DOI: 10.1108/00070700410545737

- MacLachlan. 2001. *Kill and Chill: Restructuring Canada's Beef Commodity Chain*. Toronto: University of Toronto Press.
- Manglai. 2016. Examining Record Keeping and Benchmarking Effects on the Production and Performance of Cow-calf Farms in Canada. MSc Thesis, University of Saskatchewan.
- Manitoba Agriculture, Food and Rural Initiatives. 2010. Guidelines for Estimating Based on a 150 Head Cow Herd. Retrieved from: <http://www.gov.mb.ca/agriculture/business-and-economics/financial-management/cost-of-production.html#beef>
- Mayer, David G. 2002. *Evolutionary Algorithms and Agricultural Systems*. Norwell, MA: Kluwer Academic Publishers.
- Micheels, Eric T. and Hamish Gow. 2012. The Effect of Alternative Market Orientation Strategies on Firm Performance. *International Journal of Marketing Studies*, 4(3):2-15. DOI: 10.5539/ijms.v4n3p2
- Millang, Jeff. 2002. Key Success Factors in Cow Calf Enterprise Profitability. Retrieved from: [http://www1.foragebeef.ca/\\$foragebeef/frgebeef.nsf/all/ccf120](http://www1.foragebeef.ca/$foragebeef/frgebeef.nsf/all/ccf120)
- Miller, A.S., D.B. Faulkner, R.K. Knipe, D.F. Parrett, L.L. Berger, D.R. Strohbehn. 2001. Critical Control Points for Profitability in the Cow-Calf Enterprise. *Iowa State University Beef Research Report, A.S. Leaflet R17501*. Retrieved from: <http://www.extension.iastate.edu/Pages/ansci/beefreports/mgmt01.html>.
- Nehring, Richard, Jeffery Gillespie, Charles Hallahan, James Michael Harris and Ken Erickson. 2014. What is driving economic and financial success of U.S. cow-calf operations? *Agricultural Finance Review*, 74, 3: 311-325. DOI:10.1108/AFR-02-2013-0007.
- Notter, David R., J.O. Sanders, G.E. Dickerson, Gerald M. Smith and T.C. Cartwright. 1979. Simulated Efficiency of Beef Production for a Midwestern Cow-Calf-Feedlot Management System. I. Milk Production. *Journal of Animal Science*, 49, 1: 70-82. DOI: 10.2527/jas1979.49170x
- Ochieng, Brian J. 2015. Incentives for the Adoption of Socially Beneficial Technologies: The Case of an E.Coli Vaccine. MSc. Thesis, University of Saskatchewan.
- Oginsky, Anatoliy (Senior Production Economist, Alberta Agriculture and Forestry) in personal correspondence, March 1, 2017.
- Olvera, Isaac D. 2016. Economics Implications Associated with Pharmaceutical Technology Bans in U.S. Beef Production. PhD Dissertation, Texas A&M University.

- Pang, Hang. 1997. Simulation Studies on the Effects of Cow Size, Milk Production and Calving Season on the Bioeconomic Efficiency of Beef Production. Ph.D. Dissertation, University of Alberta, Edmonton, Alberta.
- Pang, H., M. Makarechian, J.A. Basarab and R.T. Berg. 1999. Structure of a dynamic simulation model for beef cattle production systems. *Canadian Journal of Animal Science*, 79, 4: 409-417. DOI: 10.4141/A99-020
- Perloff. 2014. *Microeconomics Theory and Application with Calculus*, 3rd ed. Upper Saddle River, NJ: Pearson Education Inc.
- Peterson, John. 1989. Hormones, Heifers and High Politics – Biotechnology and the Common Agricultural Policy. *Public Administration* Vol. 67(Winter 1989): 455-471. Retrieved from: <http://onlinelibrary.wiley.com/doi/10.1111/j.1467-9299.1989.tb00741.x/abstract>. (Accessed: August 3, 2016).
- Popp, Michael P., Merle D. Faminow, and Lucas D. Parsch. 1999. Factors Affecting the Adoption of Value-added Production on Cow-Calf Farms. *Journal of Agricultural and Applied Economics*, 31, 1: 97–108. DOI: <https://doi.org/10.1017/S0081305200028806>
- Ramsey, Ruslyn, Damona G. Doye, Clement E. Ward, James M. McGrann, Lawrence J. Falconer and Stanley J. Bevers. 2005. Factors Affecting Beef Cow-Herd Costs, Production, and Profits. *Journal of Agricultural and Applied Economics*, 37, 1:91-99. URL: <http://purl.umn.edu/43687>
- Rashford, Benjamin S, Thomas Foulke, and David T. Taylor. 2010. Ranch-Level Economic Impacts of Predation in a Range Livestock System. *Rangelands*, 32, 3:21-26. DOI: 10.2111/RANGELANDS-D-10-00002.1
- Reinhardt, Chris. 2007. Growth-Promotant Implants: Managing the Tools. *Veterinary Clinics: Food Animal Practice*, 23: 309–319. <http://dx.doi.org/10.1016/j.cvfa.2007.03.004>
- Reisenauer-Leesburg, V.L., M.W. Tess and D. Griffith. 2007. Evaluation of calving seasons and marketing strategies in Northern Great Plains beef enterprises: I. Cow-calf systems. *Journal of Animal Science*, 85, 9: 2314-2321. DOI: 10.2527/jas.2007-0051
- Rich, Karl M., Brian D. Perry and Simeon Kaitibie. 2009. Commodity-based Trade and Market Access for Developing Country Livestock Products: The Case of Beef Exports from Ethiopia. *International Food and Agribusiness Management Review*, 12, 3: 1-22.
- Roberts, Casey, Clayton Spurgeon, and John Fowler. 2007. *Characteristics of the United States Organic Beef Industry*. New Mexico State University Range Improvement Task Force Report 67.

- Rotz, C.A., D.R. Buckmaster and J.W. Comerford. 2005. A beef herd model for simulating feed intake, animal performance and manure excretion in farm systems. *Journal of Animal Science*, 83, 1:231-242. DOI: 10.2527/2005.831231x
- Ruth, Matthias and Bruce Hannon. 1997. *Modeling Dynamic Economic Systems*. New York: Springer-Verlag.
- Samarajeewa, S., G. Hailu, S.R. Jeffrey, and M. Bredahl. 2012. Analysis of production efficiency of beef cow/calf farms in Alberta. *Applied Economics*, 44,3: 313-322. DOI:10.1080/00036846.2010.507173.
- Sanders, James O. 1977. Application of a beef cattle production model to the evaluation of genetic selection criteria. Ph.D. Dissertation, Texas A&M University, College Station, Texas.
- Sanders, J.O. and T.C. Cartwright. 1979a. A General Cattle Production Systems Model. I: Structure of the Model. *Agricultural Systems*, 4, 3: 217-227. DOI: 10.1016/0308-521X(79)90031-3.
- Sanders, J.O. and T.C. Cartwright. 1979b. A General Cattle Production Systems Model. Part 2- Procedures Used for Simulating Animal Performance. *Agricultural Systems*, 4, 4:289-309. DOI: 10.1016/0308-521X(79)90004-0.
- Schoepp Brenda. 2011. Know Your Full Yardage Costs. <https://www.albertafarmexpress.ca/2011/01/31/know-your-full-yardage-costs/>. Accessed March 15, 2017.
- Selk, Glenn. 1997. Implants for Suckling Steer and Heifer Calves and Potential Replacement Heifers. Presented at the 1996 Impact of Implants on Performance and Carcass Value of Beef Cattle – Symposium Oklahoma State University and Plains Nutrition Council, Tulsa OK, November 21-23.
- Short, Sarah D. 2001. Characteristics and Production Costs of U.S. Cow-Calf Operations. *United States Department of Agriculture Economic Research Service, Statistical Bulletin No. 974-3*. Retrieved from: <http://www.ers.usda.gov/publications/pub-details/?pubid=47151>.
- Smythe, Elizabeth. 2014. Can I have some hormone free beef too? The curious case of CETA, free trade and the politics of food standards. Presented at: Canadian Political Science Association Annual Meeting, Brock University, St Catharines, Ontario, May 28, 2014. Retrieved from: <https://www.assocsrvc.ca/cpsa-acsp/2014event/Smythe.pdf>. (Accessed August 24, 2016)
- Statistics Canada. 2017. Table 004-0221 - Census of Agriculture, cattle and calves on census day, every 5 years. Available from: <http://www.statcan.gc.ca/eng/ca2011/index>. (Accessed September 12, 2017).

- Statistics Canada. 2016. Table 002-0010 - Supply and disposition of food in Canada. Available from: <http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=20010> (Accessed Nov. 21, 2016).
- Statistics Canada. 2017. Table 282-0151 - Labour force survey estimates (LFS), wages of employees by type of work, National Occupational Classification (NOC), sex, and age group, unadjusted for seasonality, monthly (current dollars unless otherwise noted). Retrieved from: <http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=2820151&p2=33>. (Accessed March 2, 2017)
- Stewart, Lawton. 2013. Implanting Beef Cattle. University of Georgia Cooperative Extension Bulletin 1302. Retrieved from: <http://extension.uga.edu/publications/detail.cfm?number=B1302>
- Stokes, Kenneth W., Donald E. Farris and Thomas C. Cartwright. 1981. Economics of Alternative Beef Cattle Genotype and Management/Marketing Systems. *Southern Journal of Agricultural Economics*, 13, 2: 1-10. DOI: 10.1017/S0081305200027217
- Taylor, R.E. and T.G. Field. 1995. Achieving Cow/Calf Profitability Through Low-Cost Production. *Range Beef Cow Symposium, Paper 199*. <http://digitalcommons.unl.edu/rangebeefcowsymp/199>.
- Tess, M.W. and B.W. Kolstad. 2000a. Simulation of cow-calf production systems in a range environment: I. Model development. *Journal of Animal Science*, 78, 5: 1159-1169. DOI 10.2527/2000.7851159x
- Tess, M.W. and B.W. Kolstad. 2000b. Simulation of cow-calf production systems in a range environment: II Model evaluation. *Journal of Animal Science*, 78, 5: 1170-1180. DOI: 0.2527/2000.7851170x
- Turner, B.L., R.D. Rhoades, L.O. Tedeschi, R.D. Hanagriff, K.C. McCuiston and B.H. Dunn. 2013. Analyzing ranch profitability from varying cow sales and heifer replacement rates for beef cow-calf production using system dynamics. *Agricultural Systems* 114: 6–14. DOI: 10.1016/j.agsy.2012.07.009
- U.S. Department of Agriculture, Foreign Agricultural Service. October 2016. Livestock and Poultry: World Markets and Trade. Retrieved Oct. 12, 2016 from: <https://www.fas.usda.gov/data/livestock-and-poultry-world-markets-and-trade>
- Verified Beef Production Plus. 2017. What is VBP+. Retrieved from: <http://verifiedbeefproductionplus.ca/about-vbp/what-is-vbp.cfm>.
- Vogel, David. 1995. Trading Up: Consumer and Environmental Regulation in a Global Economy. Harvard University Press: Cambridge Massachusetts
- Western Beef Development Centre. 2015. *2014 Western Cow-Calf Survey Aggregate Results*.

- Whitson, R.E. 1975. Ranch Decision-Making under Uncertainty: An Illustration. *Journal of Range Management*, 28, 4: 267-270. URL: <http://www.jstor.org/stable/3897772>.
- Wiegel, Whitney J. 2009. Adoption of Organic Farming Systems in Missouri. MSc. Thesis, University of Missouri – Columbia
- Woodworth, Bruce M. 1973. Optimizing the Calf Mix on Range Lands with Linear Programming. *Journal of Range Management*, 26, 3: 175-178. URL: <http://www.jstor.org/stable/3896685>.

APPENDIX A: Tag Replacement Report

Facility name: _____

Address/Location: _____

Premise identifier: _____

The animal bearing Approved tag
number _____

(if applicable), was found to have lost its tag but the identity of this animal was confirmed by the
following means:

It was retagged with Approved tag number: _____

Date the animal was retagged and reported: _____

Owner/Responsible Person
(print): _____

Signature: _____

APPENDIX B: Register for Birth Farms

Growth Enhancing Product Free Cattle

Reference # _____

Page _____

Name of producer
applicant: _____

Legal name of business: _____

Location and/or Canadian Cattle Identification Agency / Agri-Traçabilité Québec / Provincial
Premises ID: _____

Register for Birth Farms

Approved Tag #	Alternate Tag # (Compulsory for Mixed Farms)	Transfer Certificate # and Date

APPENDIX C: Transfer Certificate

Annex R-7 Transfer Certificate				
Name and Address of Owner / Responsible Person	Date of Transfer	# of Animals	Premise ID	Reference # (example: 2011-001)

Are GEPs present on the farm of origin?

Yes ☐ | No ☐

Were these cattle on community pasture/forestry reserves at any time?

Yes ☐ | No ☐

Were these cattle sold through a public auction market?

Yes ☐ | No ☐

Listing of animals can be entered below or attached

Note : Listing of animals can be entered below or attached		Check box if listing document is attached <input type="checkbox"/>	
Approved Tag	Alternate ID	Approved Tag (Con't)	Alternate ID (Con't)

Transfer to:	Name and Address of Destination
<input type="checkbox"/> Farm or Feedlot	
<input type="checkbox"/> Auction Market	
<input type="checkbox"/> Federally Registered Meat Establishment for Slaughter	

Producer Declaration

I, (Name) _____, am the present owner of/the responsible person for the identified animals above or on attached listing consisting of # _____ pages with reference # _____ and have directly controlled or take full responsibility for relevant practices applied in their raising while under my control. If the animals have been owned by other persons I am in possession of a copy of the Transfer Certificate like this one from the previous owner or responsible person. I declare that the animals covered by this declaration have not been administered any Growth Enhancing Products when they were under my control.

Signature: _____

Date: _____

APPENDIX D: Weighted Average Sensitivity Analysis

	Saskatchewan BE (% Change from WA)	Weighted Average BE	Alberta BE (% Change from WA)
EU Compliant	1.5573 (-5.95%)	1.6559	1.7281 (4.36%)
Scenario A	1.4968 (-5.99%)	1.5922	1.6620 (4.38%)
Scenario B	1.5071 (-5.95%)	1.6025	1.6724 (4.36%)
Scenario C	1.5428 (-6.00%)	1.6414	1.7136 (4.40%)
Scenario D	1.5535 (-5.96%)	1.6520	1.7242 (4.37%)